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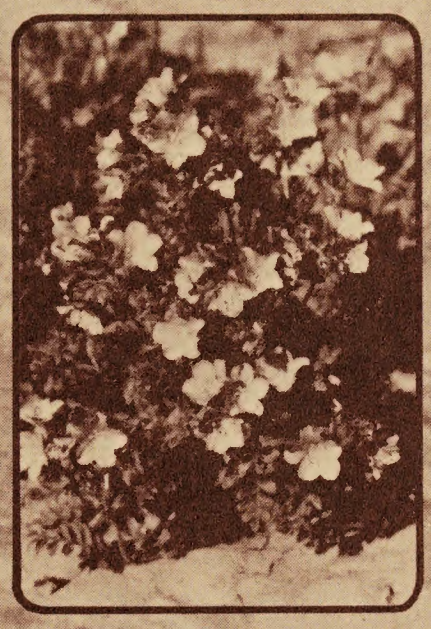
ft Environmental Impact Statement
and Draft Regulations

Proposed Oil and Gas Exploration Within the Coastal Plain of the Arctic National Wildlife Refuge, Alaska



U.S. Department of the Interior

CONVERSION TABLE

Throughout this document data are presented in either U.S. Customary Units or SI Metric Units (International System of Units (SI)), or both, according to their presentation in the reference material to prevent possible distortion or misinterpretation of the data. For reader convenience, a conversion table is presented below.

To convert U.S. Customary Unit	Multiply by	To obtain SI Metric Unit
	LENGTH	
Inches (in.)	25.4	Millimeters (mm)
Inches (in.)	2.54	Centimeters (cm)
Feet (ft)	0.3048	Meters (m)
Miles (mi)	1.609	Kilometers (km)
	AREA	
Acres	0.4047	*Hectares (ha)
Square miles (mi^2)	2.59	Square kilometers (km^2)
Section (640 acres or 1 mi^2)	259.0	Square hectometers (hm^2)
Square feet (ft^2)	92.90×10^{-3}	Square meters (m^2)
	VOLUME	
Acre-feet	1.233×10^{3}	Cubic meters (m^3)
Acre-feet	1.233×10^{-3}	Cubic hectometers (hm^3)
Acre-feet per square mile (acre-feet/mi^2)	4.76×10^{2}	Cubic meters per square kilometer (m^3/km^2)
Barrels (bbl) (petroleum, 1 bbl = 42 gal)	0.159	Cubic meters (m^3)
	VOLUME PER UNIT TIME (includes flow)	
Cubic feet per second (cfs or ft^3/s)	2.832×10^{-2}	Cubic meters per second (m^3/s)
Gallons per minute (gpm or gal/min)	6.309×10^{-2}	Liters per second (L/s)
Gallons per minute (gpm or gal/min)	6.309×10^{-5}	Cubic meters per second (m^3/s)
	TEMPERATURE	
Degrees Fahrenheit (^oF)	=	1.8 temp $^oCelsius$ + 32
	HEAT PER UNIT MASS	
British thermal units per pound (Btu/lb)	2.326	Kilojoules per kilogram (kJ/kg)

To convert SI Metric Unit	Multiply by	To obtain U.S. Customary Unit
	LENGTH	
Millimeters (mm)	39.37×10^{-3}	Inches (in.)
Centimeters (cm)	0.3937	Inches (in.)
Meters (m)	3.281	Feet (ft)
Kilometers (km)	6.214×10^{-1}	Miles (mi)
	AREA	
Hectares (ha)*	2.471	Acres
Square hectometers (hm^2)	3.861×10^{-3}	Section (640 acres or 1 mi^2)
Square kilometers (km^2)	0.3861	Square miles (mi^2)
Square meters (m^2)	10.76	Square feet (ft^2)
	VOLUME	
Cubic meters (m^3)	8.107×10^{-4}	Acre-feet
Cubic meters (m^3)	6.290	Barrel (bbl) (petroleum, 1 bbl = 42 gal)
Cubic hectometers (hm^3)	810.7	Acre-feet
Cubic meters per square kilometer (m^3/km^2)	2.10×10^{-3}	Acre-feet per square mile (acre-feet/mi^2)
	VOLUME PER UNIT TIME (includes flow)	
Cubic meters per second (m^3/s)	35.31	Cubic feet per second (cfs or ft^3/s)
Cubic meters per second (m^3/s)	15.850×10^{3}	Gallons per minute (gpm or gal/min)
	TEMPERATURE	
Degrees Celsius (^oC)	=	(temp $^oFahrenheit$ -32)/1.8
	HEAT PER UNIT MASS	
Kilojoules per kilogram (kJ/kg)	42.99×10^{-2}	British thermal units per pound (Btu/lb)

*Use of hectare (ha) as an alternative name for square hectometer (hm^2) is restricted to the measurement of land or water areas.

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Draft Environmental Impact Statement
and Draft Regulations

Proposed Oil and Gas Exploration Within the Coastal Plain of the Arctic National Wildlife Refuge, Alaska

September 1982

Type of Action: Administrative

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Prepared by the U.S. Fish and Wildlife Service
in cooperation with the U.S. Geological Survey
and U.S. Minerals Management Service

U.S. FISH & WILDLIFE SERVICE
DEPARTMENT OF THE INTERIOR

Robert A. Jantzen

Director
U.S. Fish and Wildlife Service

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Front cover: Background photograph: Unit IIa, Pond Complex, showing ponds and aquatic communities in the basins of low-centered polygons. Photograph by D. A. Walker, Institute of Arctic and Alpine Research, University of Colorado. Inset photographs from the files of the U.S. Fish and Wildlife Service, Region 7, Anchorage, Alaska.

Cover design: Edward Swibas and Arthur Isom,
U.S. Geological Survey

COVER SHEET

DRAFT ENVIRONMENTAL IMPACT STATEMENT
AND
DRAFT REGULATIONS

Proposed Oil and Gas Exploration within the Coastal Plain of the Arctic National Wildlife Refuge, Alaska

September 1982

Prepared by: U.S. Fish and Wildlife Service, Alaska Region
1011 E. Tudor Road, Anchorage, Alaska 99503

Information contact: (907) ~~263~~ 564-3800 (Jan Riffe)

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Cooperating Agencies: U.S. Geological Survey and Minerals Management Service

Abstract: The proposed action is to establish, by regulation, initial guidelines to govern aerial and surface geological exploration or geophysical exploration, or both, for oil and gas within the coastal plain of the Arctic National Wildlife Refuge in a manner that avoids significant adverse effects on the fish and wildlife, their habitats, or the environment. The proposed regulations (appendix A) accompanying this EIS were developed in consideration of the probable impacts of such exploration and were designed to prevent significant adverse effects, while permitting applicants to choose the exploratory methods and techniques they wish to use as long as these exploratory activities satisfy the environmental protections contained in the regulations. Alternatives to these proposed regulations evaluated in this EIS include Regulations Authorizing Government-Prescribed Operations, Regulations Authorizing Applicant-Defined Operations, and No Action (no regulations). In assessing the impacts of exploratory activities, four methods of seismic exploration are evaluated in detail, since seismic exploration provides the best methods allowed under the act to estimate the location and volume of oil and gas resources. These seismic methods are: (1) winter operations using helicopters to transport equipment and personnel; (2) winter operations using ground-surface vehicles for transport (cat-trains); (3) summer operations using helicopters for transport; and (4) summer cat-train operations. Impacts of these seismic methods are largely determined by season of the year and mode of access. Some variation in impacts would result from the seismic technique used: (1) air-shot (Poulter); (2) conventional (below-ground explosives); and (3) mechanical (vibration or Vibroseis).

Last date to accept comments: November 1, 1982.

SUMMARY

PURPOSE AND NEED

The Alaska National Interest Lands Conservation Act (ANILCA) became law on December 2, 1980, 16 U.S.C. 3101-3233. Section 1002 of ANILCA (16 U.S.C. 3142) (appendix D) provides for a comprehensive and continuing inventory and assessment of the fish and wildlife of the coastal plain of the Arctic National Wildlife Refuge (ANWR) and an analysis of the impacts of oil and gas exploration, development, and production. Exploratory activities within the coastal plain are authorized in a manner that avoids significant adverse effects on fish and wildlife, their habitats, or the environment. By June 1982, the Secretary was to publish results of the continuing study of fish and wildlife resources, followed by revisions as new information is obtained. This baseline study was published April 1982 (Baseline Study, U.S. Fish and Wildlife Service, 1982). The Secretary of the Interior is required to establish, by regulation, initial guidelines to govern exploratory activities. The guidelines are to be based on the results of the initial baseline study and other information as may be available to the Secretary and are to be accompanied by an environmental impact statement (EIS) on exploratory activities.

To ensure that exploratory activities do not have significant adverse effects on fish and wildlife, their habitats, or the environment, the regulations must include but are not limited to:

- o A prohibition on the carrying out of exploratory activities during caribou calving and immediate postcalving seasons or during any other period in which human activity may have adverse effects;

- o Temporary or permanent closing of appropriate areas to such activity;

- o Specification of the support facilities, equipment, and related manpower that is appropriate in connection with exploratory activity; and

- o Requirements that exploratory activities be coordinated in such a manner as to avoid unnecessary duplication.

After the initial regulations are promulgated and the EIS is finalized, any person, including the United States Geological Survey (USGS), may submit to the Secretary one or more exploration plans. An exploration plan must set forth such information as the Secretary may require in order to determine whether the plan is consistent with the regulations. As a condition of approval of any plan, the Secretary:

- o May require that such modifications be made to the plan as he considers necessary and appropriate to make it consistent with the regulations;

- o Shall require that all data and information (including processed, analyzed, and interpreted information) obtained as a result of carrying out the plan shall be submitted to the Secretary; and

- Shall make such data and information available to the public, except that any processed, analyzed, and interpreted data or information shall be held confidential by the Secretary for a period of not less than 2 years following any lease sale including the area from which the information was obtained.

BACKGROUND

By memorandum dated March 12, 1981, the Secretary transferred responsibility for drafting the exploration regulations and EIS from the U.S. Fish and Wildlife Service (FWS) to USGS. The Public Notice of Intent to draft the regulations and prepare an EIS for oil and gas exploration on ANWR was published in the Federal Register, July 14, 1981. Public meetings to identify issues and scope the EIS were conducted by USGS in Anchorage, Fairbanks, Kaktovik, Arctic Village, and Barrow, Alaska; and Washington, D.C., during August and September 1981. A memorandum of understanding (MOU) was drafted between FWS and USGS, designating FWS as joint lead for preparing the regulations and EIS, with USGS maintaining administrative lead. Before this MOU was formalized, however, the U.S. District Court for the District of Alaska ruled, on November 2, 1981, in a suit brought by Trustees for Alaska and other plaintiffs, that full responsibility for preparation of the regulations and EIS had to be reassigned to FWS. In a December 4, 1981, final Declaratory Judgment, the Court disapproved an existing draft of the regulations, EIS outline, and exploration assumptions prepared by USGS and directed that new ones be developed by FWS. The draft regulations disapproved by the court were designed to provide a moderate level of guidance by setting forth performance standards for applicants to meet in order to protect ANWR's fish and wildlife, their habitats, and the environment, and to divide certain responsibilities for regulating exploratory activities between USGS and FWS. In the court's December 4 order, the FWS was also directed to prepare documentation containing the determinations of the Alaska Regional Director, FWS, as to which portions of the work, actions, and products to that date were approved, approved in part, or disapproved.

As a result of the court's November 2, 1981, decision, FWS assumed lead agency responsibility and began anew the tasks required by Section 1002. The district court's ruling was appealed to the Court of Appeals for the 9th Circuit by the Secretary on February 19, 1982, and its decision is currently pending. Because of their technical expertise in mineral exploration and development, the USGS and the Minerals Management Service (MMS), which was established by the Secretary on January 19, 1982, and which was assigned some of USGS' former responsibilities, have assisted the FWS in the preparation of this EIS as cooperating agencies.

SCOPING ISSUES

The public meetings identified a number of issues related to oil and gas exploration on ANWR. As would be expected, many of the views and concerns expressed by environmental and Native groups either differed from or conflicted with those of industry. However, environmental and Native groups and industry representatives were in general agreement that all feasible alternative methods of oil and gas exploration should be considered, with selection of the one(s) that will provide the essential data with no significant adverse effect.

Concerns of Environmental Groups

The following list summarizes the primary concerns expressed by environmental groups during the scoping process. The preamble to the proposed regulations (appendix A) discusses how they generally reflect these concerns.

- o The FWS should have lead for preparing the EIS and regulations.
- o Exploration should be undertaken in winter rather than summer to lessen risk of significant impacts.
- o The timeframe between completion of the Baseline Study and development of the EIS and regulations is too short. The EIS, Baseline Study, and regulations should be written sequentially rather than simultaneously.
- o Exploration activities should be monitored by FWS personnel having authority to make decisions to modify or stop activities that would result in significant or avoidable impacts.
- o Seismic information should be made public immediately.
- o Alternatives to resource development should be considered in the EIS. Alternatives should be analyzed and compared on the basis of unavoidable impacts.
- o Wilderness review should be undertaken concurrently with the Baseline Study.
- o Adequate archeological surveys should be conducted prior to exploratory activities.
- o No duplicative exploration should be permitted.
- o Critical environmental areas should be identified and excluded from exploratory activities.

Concerns of Industry Representatives

Industry representatives expressed the following concerns during the scoping process:

- o Acquisition of high-resolution data and use of appropriate technologies should be allowed.
- o Industry responses to questions in the "Notice of Intent" should be printed in the EIS.
- o Confidentiality of collected data should be protected for 10 years following leasing.
- o Any airborne surveys should precede surface work by one season.
- o Each applicant should be allowed to do his own exploration, if desired.
- o No restriction should be imposed on the number of field crews.

- o Consideration of exploratory activities should not be restricted the to winter season.

- o The low probability of worst-case scenarios should be accurately emphasized.

- o No portion of the ANWR coastal plain should be excluded from exploration.

- o Some duplication of exploratory work should be permitted if found necessary for accurate data interpretation.

Concerns of Local Citizens

Subsistence issues were the major concerns expressed by representatives of the Native community:

- o Exploration should not harm caribou, caribou calving grounds, polar bears, wolves, ground squirrels, or ptarmigan, or rivers and streams that contain overwintering fish.

- o Native guides should be assigned to exploration crews to ensure the protection of archeological, cultural, and historical sites.

- o Winter season activity is preferred.

- o Documents leading to exploratory activity should clearly outline exploratory assumptions of the project.

Concerns of Other Government Agencies

- o The EIS should address the rationale for choosing the preferred alternative and the proposed regulations.

- o The issue of possible drainage disruption on the coastal plain should be addressed along with the potential for permafrost degradation.

ALTERNATIVES

Regulating oil and gas exploration on ANWR can be accomplished through a variety of regulatory schemes. Alternatives for varying levels of regulatory control are described below.

Alternative 1. Regulations Authorizing Government-Prescribed Operations

Alternative 1, Regulations Authorizing Government-Prescribed Operations, would provide the most detailed guidance and strongest governmental control of the three alternatives considered. These regulations would be extremely detailed in prescribing permissible exploratory activities on a seasonal and site-specific basis. Supplemental stipulations would be largely unnecessary since all contingencies would presumably be covered by these detailed regulations. The study area would be broken down geographically into small areas on the basis of habitat sensitivity and wildlife use criteria. The regulations would stipulate the season, duration, and type of exploratory method and technique allowed in each

area, the assumption being that more, or less, stringent exploratory controls would be exercised in different areas in accordance with the varying levels of sensitivity. This degree of guidance assumes site-specific data in excess of those which presently exist. Therefore, it is essential that all exploration activities be controlled on the basis of the impacts which would occur on the most sensitive areas until more detailed baseline studies are completed. This alternative would require an increase in current levels of personnel and funding. Also, it would reduce flexibility to alter exploratory activities as field experience is gained. This alternative could be slightly more flexible if, instead of providing guidance through detailed regulations, the FWS Regional Director was empowered by the regulations to provide guidance and control through the development of operational stipulations. However, the funding and administrative problems would remain largely the same. Also, to attempt to develop site-specific criteria prior to the collection and evaluation of additional site-specific environmental data could constrain applicants in terms of types of methods and techniques, equipment, and support facilities that could be used and timeframes permitted for work.

It is believed that regulations and subsequent operations conducted under this alternative scheme could result in essentially the same types of impacts as under the proposal. However, because of uncertainties due to the present lack of detailed, site-specific biological data, more areas might be excluded from exploration as a precautionary measure. While this may result in fewer environmental impacts occurring than might be expected under alternatives 2 or 3, it could prevent an adequate assessment of the coastal plain and result in insufficient data regarding its oil and gas resource potential.

Alternative 2. Regulations Authorizing Applicant-Defined Operations

Alternative 2, Regulations Authorizing Applicant-Defined Operations, would reiterate the standard of no significant adverse effects as expressed in Section 1002 of ANILCA and state in very general terms any prohibitions, restrictions, and conditions on exploratory activities necessary to satisfy that standard. Applicants would be required to develop exploration plans which would assure the Secretary that no significant adverse impacts would occur. To further ensure no significant impact, full-time FWS monitors with authority to halt or modify an operation would be present on each exploration crew. This regulatory scheme would allow for the development of a greater variety of plans and would allow the applicant to dictate when and where exploratory activities would take place under approved plans. However, lack of site-specific guidance could impose a greater burden on the applicant than would alternatives 1 or 3. Also, because of the possible variety of plans submitted for approval, it is likely that those approved would result in a greater variety of impacts than would occur under more specific guidance, thus increasing the amount of onsite monitoring required. The greater the reliance on monitoring to prevent significant adverse impacts, the greater the opportunity for impacts to occur before enforcement action can be taken. This alternative would provide for less control over finding plans consistent with the regulations; thus, more plans would be approved.

Although operations permitted under this regulatory alternative would result in essentially the same types of impacts as those under the proposed action, the numbers and magnitude of impacts could be greater. For example, the proposed regulations delineate special use areas to protect other wildlife in addition to caribou that would be avoided either entirely or during certain timeframes. No

such areas would be defined by regulations if this alternative is selected. Disturbances to sensitive landcover types and archeological resources are more likely to occur without guidance on restricted entry, adequate protective cover, blading and compaction, and solid-waste disposal. Fish and wildlife disturbance is more likely to occur in the absence of specific guidance as to the use of explosives, wildlife harrassment, vehicle operation, and delineation of special muskoxen calving areas and brown bear denning areas, etc. There is also a much greater potential for cumulative impacts under this regulatory option.

Alternative 3. The Regulations as Proposed (Proposed Action)

Alternative 3, The Regulations as Proposed (Proposed Action), reflects a moderate level of regulatory guidance (appendix A). The proposed regulations are designed to provide limitations and environmental safeguards to prevent significant adverse impacts, yet give applicants flexibility for an efficient and effective exploration program. They permit an applicant to choose among geological and geophysical methods and techniques as long as the applicant shows that he satisfies the requirements of the regulations and the act. The draft regulations were developed in consideration of probable impacts of aerial and surface geological and geophysical methods. Requirements and procedures for submitting exploration plans are outlined in subpart C, sections 37.2 through 37.25 of the proposed regulations.

Surface geological exploration alone cannot provide the detailed data required to predict the location and volume of oil and gas. Geophysical surveys are necessary to provide the required information. Three types of geophysical surveys were evaluated--magnetic, gravity, and seismic. Because magnetic and gravity geophysical methods do not require exploratory drilling, they have been included as a supplement to the seismic method. Given the character of the magnetic and gravity methods, the design of the proposed regulations to allow them to be permitted is believed consistent with the act. Of the magnetic and gravity surveys, the latter would result in data that are the most useful to the proposed exploration program by providing general information sufficient to determine areas having little or no potential for oil and gas deposits. On the basis of this preliminary information, more detailed seismic surveys could be conducted in the remaining areas on ANWR, thus avoiding any unnecessary disturbance of areas determined to have poor oil and gas resources potential.

Four seismic survey methods were identified on the basis of season and access mode, each of which can be accomplished by two or three different techniques. All four methods share the following charcteristics: A typical operation would follow a series of survey lines transecting the study area. Lines would generally be spaced at intervals of 2 to 10 miles and would intersect and be perpendicular to a second series of lines spaced at similar intervals in the pattern of a grid. Each of the techniques utilized for collection of data would employ a different method to induce energy into the earth along the lines at intervals (or multiples) of 220 feet. With each technique, reflected energy would be recorded by groups of geophones placed on the ground in an array around the energy source. These methods are: (1) winter operations using helicopter to transport equipment and personnel; (2) winter operations using ground-surface vehicles for transport (cat-trains); (3) summer operations using helicopters for transport; and (4) summer cat-train operations. Impacts of these seismic methods are largely determined by

season of the year and mode of access. Some variation in impacts would result from the seismic technique used: (1) air-shot (Poulter); (2) conventional (below-ground explosives); and (3) mechanical (vibration or Vibroseis).

Alternative 4. No Action

Alternative 4, No Action, would be the decision to not establish guidelines by promulgating regulations for oil and gas exploration. Such decision could result from congressional action to specifically repeal this statutory requirement or from the conclusion that all exploratory methods and techniques that might be proposed would result in significant adverse impacts that could not be mitigated. No Action would result in the continuation of the fish and wildlife management programs currently being carried out on the ANWR coastal plain as part of the National Wildlife Refuge System. The data and information on potential oil and gas resources that the 1002 program is intended to generate would not be obtained.

AFFECTED ENVIRONMENT

The coastal plain study area of ANWR is bordered by the Brooks Range on the south and the Beaufort Sea on the north. It is bounded on the east by the Aichilik River and on the west by the Canning River. The land area of approximately 1.4 million acres extends from east to west for approximately 100 miles and ranges from about 15 to 50 miles in width, north to south. The coastal plain is essentially pristine, with evidence of human presence limited to two settlements, two abandoned airstrips, and some fading evidence of vehicle tracks along the coast as a result of military construction and USGS mapping activities prior to designation of the area as the Arctic National Wildlife Refuge.

The only permanently inhabited settlements within the ANWR boundary are the village of Kaktovik, with a 1980 population of 165 inhabitants, mostly Inupiat Eskimo (18 non-Native), and the nearby U.S. Air Force Distant Early Warning (DEWLine) site occupied by approximately 70 personnel. Both settlements are located on Barter Island, immediately off the coast, about midpoint along the ANWR coastline, north of the coastal plain study area. Kaktovik has survived as a community because of family and cultural ties, ties to the land, and the economic opportunities of both jobs and subsistence. Most of Kaktovik's present subsistence land use is within ANWR. Kaktovik residents depend primarily on caribou, sheep, bowhead whales, fish, waterfowl, and other birds for subsistence. Seals, polar bears, furbearers, and small game are secondary subsistence species.

The area is relatively arid, with average annual precipitation being less than 25 cm (10 inches), mostly in the form of summer rainfall. Shallow soils are underlain with permafrost, and the ground surface remains frozen from about mid-September to mid-May. Streamflow essentially ceases during late winter. Summers are characterized by cold maritime winds, frequent cloudiness, fog, light rain, and continuous light. In winter, cloudiness decreases, very cold winds prevail, and at Barter Island the sun remains below the horizon for nearly 2 months. Snow is usually present by mid-September and increases to as much as 3 feet by March and April. Depending upon topography and its modifying influence upon prevailing windflow, snow cover accumulates in patches and strips, leaving some exposed areas.

Landcover of the entire coastal plain lies within the tundra formation. The land is mostly continuously vegetated with low-growing plants, such as sedges, grasses, lichens, small herbs, and dwarf shrubs. Taller shrubs, such as willow, are restricted to drainages protected from winter winds and snow abrasion and to slopes with southern exposures that get the most sunlight.

Topographically, there are significant differences between the western and eastern coastal plain. The area west of the Hulahula River is predominately rolling tundra, characterized by numerous streams, few lakes, uneven ground and tussocks. Snow tends to be blown from ridgetops and collects in deep drifts and sheltered swales. East of the Hulahula River the terrain is relatively devoid of relief and is very similar to the Prudhoe Bay and NPR-A coastal plain.

Wildlife use of the coastal plain is largely seasonal, although there are some resident species. The most numerous inhabitants of the coastal plain are caribou and migratory waterbirds.

Caribou

The Porcupine Herd of approximately 110,000 caribou constitutes one of the largest herds in North America. The two principal wintering areas for this herd are located in the central portion of the Yukon Territory, Canada, and in the vicinity of Arctic Village, Alaska, on the south side of the Brooks Range. In recent years, most of the herd has wintered in Canada. Spring migration occurs in April and early May. Calving occurs in late May and early June, and location varies, extending along the foothills and coastal plain from the Babbage River in Canada to the Canning River in Alaska. The herd forms into large postcalving aggregations in late June and begins its eastward migration. The majority of the herd passes into Canada between the first and second week of July, although as much as 10 percent of the herd may remain on ANWR until mid-August.

Portions of the distinctly separate Central Arctic Caribou Herd, numbering as many as 10,000, may reside year-round on the ANWR coastal plain. The foothills are utilized more intensively by these animals during winters of unusually harsh weather conditions. Eskimo hunters from Kaktovik commonly hunt caribou during the winter in the vicinity of Peters and Schrader Lakes, Hulahula River, Jago River, and the Sadlerochit Mountains. In some years, winter harvest of caribou from these bands provides a significant portion of the subsistence resources for residents of Kaktovik.

Waterbirds

The majority of bird species using the ANWR coastal plain are migratory and occur in significant numbers from May to September. A total of 108 species have been recorded. The lagoon systems are important feeding areas for oldsquaw, eiders, scoters, other ducks, loons, phalaropes, terns, gulls, jaegers, and black guillemots. White-fronted geese and lesser snow geese migrate by the thousands along the seacoast in spring and fall. Canada geese and brant are the only species of geese which commonly breed on ANWR. Whistling swans are common breeders, as are many species of shorebirds, seabirds, loons, and ducks. Most waterbirds begin arriving in late May and begin departing in July and August, although some do not leave until as late as mid- or late September.

Other Wildlife

Raptors which nest in the area include rough-legged hawks, golden eagles, gyrfalcons, snowy owls, and short-eared owls. The endangered arctic peregrine falcon has not recently been observed nesting in the study area but seasonally has been observed migrating along the seacoast. Willow and rock ptarmigan are common residents of the coastal plain. Many species of passerines (perching birds) utilize the study area during the summer.

Muskoxen were reintroduced to the ANWR coastal plain in 1969 and 1970 after having been extirpated by man prior to 1900. There are presently three groups on the coastal plain totaling about 200 animals. These animals are not migratory and tend to remain near major drainages. Feeding movement in summer is generally linear in relation to riparian habitat, as the muskoxen move along the river drainages. Winter distribution is primarily controlled by distribution of favored forage species (willow) and snow-cover conditions.

Moose are not abundant in the study area. They typically overwinter along streams in foothills and hilly coastal plain tundra. Following calving in late May or early June, a significant but unknown portion of the animals disperse on the coastal plain habitats for the summer.

Although Dall sheep numbered an estimated 6,800 on ANWR in 1979, only a few are in the coastal plain study area. They have been observed using the lower foothill terrain near Sadlerochit Spring, mostly in winter.

Wolves, arctic foxes, and wolverines range throughout the study area. Wolves are widely dispersed and are seldom seen in the summer. In winter, wolf packs tend to congregate near overwintering caribou. Little is known about wolverines in the ANWR study area. Arctic foxes are a main predator of ringed seals when the newborn seals are in the birth lair and are opportunistic feeders on remains of polar bear kills.

Brown bears occupy large home ranges (100 to 300 mi^2) on ANWR due to scarcity of food and cover. Willow thickets along river valleys are areas of concentrated activity. Denning occurs in October, and the bears emerge in April and May. Summer activity is restricted primarily to alpine tundra, foothills, and hilly coastal plain habitats.

Polar bears are associated primarily with the ice pack year-round; however, some denning occurs on the mainland and offshore islands. Cubs are born in December and leave the dens in March or April.

Ringed seals, bearded seals, and spotted seals occur in coastal and marine environments offshore from the study area.

The bowhead and gray whales occur offshore from the study area, and both are listed as endangered species. The occurrence of gray whales in the Beaufort Sea is extremely rare. Belukha (beluga) whales, not listed as endangered, occur in the same waters. These mammals are present offshore in the Beaufort Sea only during short periods of open water in late summer.

Fish

Relatively few fish species occur in the Arctic marine, estuarine, and freshwater environments of ANWR. Arctic cod and flounder occupy saltwater habitat; anadromous arctic char may be found in marine, estuarine, and freshwater habitats. Some coastal lakes with outlets contain arctic cisco, arctic char, grayling, and round whitefish during summer and fall. Most lakes are too shallow to overwinter fish and are utilized only for feeding during open-water periods. Overwintering habitat is probably the main limiting factor for Arctic fish populations.

Cultural Resources

Archeological investigations on ANWR during the last 30 years have not provided comprehensive coverage. Former surveys focused on very limited geographic areas and, generally, selectively sampled only some of the locales where archeologists expected to find sites, thereby skipping areas assumed to have low site frequencies. This has left large gaps in the data base regarding settlement system and changing land use patterns and the basic chronology of the cultural occupation sequences. Many questions remain unanswered regarding the cultural processes that produced the sequences of human occupations (now represented only in archeological sites), environmental influences on these processes, and the social behavior that resulted from and produced these processes. Even though the previous investigations have been limited in scope and intensity, they have identified over 50 prehistoric and historic sites representing at least 6,000 years of human occupation within ANWR. Research in adjacent areas in north Alaska and Canada clearly indicate that the ANWR study area is within one of the two most probable northern entry routes for the first human inhabitants of the Western Hemisphere from the mainland of Asia. Thus, it can be expected that sites representing at least 12,000 years of human occupation, from Paleoindian times to the present, may be found within the coastal plain study area of ANWR. These sites, both early and recent, could yield data of great scientific and cultural value because so little is known of the sequence of human occupations and culturally defined land use patterns for this region.

ENVIRONMENTAL CONSEQUENCES

Section 1002(d) requires initial guidelines to be established, by regulation, which contain prohibitions, restrictions, and conditions necessary or appropriate to ensure that exploratory activities do not significantly adversely affect the refuge's fish and wildlife, their habitats, or the environment. Regardless of the regulatory option selected, there will be some degree of unavoidable adverse impacts. Following is a summary of the unavoidable impacts associated with seismic survey methods. Figure S-1 displays the relative impacts of these methods on various species and resources.

Winter Access by Ground Vehicle

Some soil and vegetation disturbance is inevitable with a cat-train operation. The requirement for sufficient snow and/or a frostline as outlined by the proposed action may preclude portions of the study area from cat-trains if it is determined that resulting adverse impacts are significant and unavoidable. Windblown snow patterns may result in extensive exposed or insufficiently protected ground

EXPLANATION

- No measurable impact
- • Minor impact
- ● Moderate impact
- ⬤ Significant impact

OIL & GAS EXPLORATION METHODS	RESOURCES														
	Vegetation-Soils	Caribou	Wolves	Wolverines	Brown bears	Polar bears	Muskoxen	Waterbirds	Fish	Endangered species	Socioeconomics	Esthetics	Wilderness	Recreation	Archeology
SURFACE GEOLOGICAL EXPLORATION		•			•		•	•		•				•	
GEOPHYSICAL EXPLORATION															
Magnetic survey		•					•	•						•	
Gravity survey	•	•	•	•	•		•	•		•	•			•	•
Seismic survey															
Winter access by ground vehicle															
Mechanical	●	•	•	•		•	•		•		•	●	●	●	●
Conventional	●		•	•		●	•		•		•	●	●	●	●
Air shot	●	●	•	•		•	●		•		●	●	●	●	•
Winter access by helicopter															
Mechanical[1]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Conventional		•	•	•		•	•				•			•	•
Air shot		•	•	•		•	•				•			•	•
Summer access by ground vehicle															
Mechanical	●	●	●	•	•		•	●	●	•	•	●	●	●	●
Conventional	●	●	●	•	•		•	●	●	•	•	●	●	●	●
Air shot	●	●	●	•	•		•	●	●	•		●	●	●	●
Summer access by helicopter															
Mechanical[1]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Conventional	•	●	•	•	•		●	●	•	•	●	•	•	●	•
Air shot		●	●	•	•		●	●	•	•	●			●	•

[1]Technically infeasible

Figure S-1.--Unavoidable impacts of exploration activities.

surfaces. Hilly terrain is particularly susceptible to damage when blading or plowing deep drifts becomes necessary or where vehicle traction is difficult to obtain. Although biological activity is at its lowest ebb during the winter, equipment noise and human activity can adversely affect those animals that are present, especially polar bears and muskoxen. The proposed regulations will ensure temporary closure of sensitive areas, such as those occupied by muskoxen or denning polar bears, to prevent significant adverse impacts on wildlife or other resources. The proposed regulations also provide for the inclusion of terms and conditions in special use permits as necessary to ensure environmental protection. Wintering caribou are less likely to be seriously affected, although shifts in animal distribution as a result of seismic activity may interfere with subsistence hunting. There is little difference in impacts that would result from mechanical versus conventional surveys, although a slightly greater noise factor is possible with the conventional survey because of the more frequent aircraft flights. The air-shot method would have the greatest noise disturbance impact on animals because of the above-ground detonation of explosives. On the other hand, ground-surface impacts would be less, as vehicles required to transport heavy vibrating machines or drill rigs would not be necessary.

Winter Access by Helicopter

Because this method does not require ground vehicles, surface impacts from helicopter access are not expected. Some minor physical impacts could be associated with temporary camps, which would have to be located within 15 minutes' flying time from work areas. Noise impacts would be greater than those for cat-train operations because of the greater and farther reaching sound and the numerous flights required by low-flying helicopters. This impact will be minimized, but not entirely eliminated, as a potential disturbance factor to muskoxen and denning polar bears by placing appropriate conditions and terms in special use permits and creating temporary closure areas designated for protection of those species. Disruption to other species, primarily caribou, and major scavangers and predators, such as foxes, wolverines, and wolves, would also be greater with this method than would a cat-train operation. Limitations associated with this method are the greater risk to human safety and the relatively short winter periods in which helicopter use would be practicable. Mechanical surveys could not be conducted due to the weight of the required equipment. Helicopter-transported seismic exploration would have the least adverse impact of the seismic methods, inasmuch as noise would affect relatively few animals and ground-surface impacts would be negligible.

Summer Access by Ground Vehicle

This is the most damaging seismic method and would result in significant unavoidable adverse impacts to esthetic, recreational, archeological, and wilderness values (fig. S-1). Analysis of this method has led to the conclusion that the environmental impacts from the summer operation of ground vehicles would be unacceptable under the statutory standard of no significant adverse effect and, for this reason, the proposed regulations preclude a permittee from choosing this option.

Summer Access by Helicopter

Ground surface and aquatic impacts would be minor with a helicopter-transported summer seismic operation. Equipment sound and human activity could be potential disturbance factors to breeding, calving, and nesting activities. The proposed regulations prohibit exploratory activities from occurring in caribou calving and postcalving areas and prohibit the use of helicopters in areas being used by nesting and staging waterbirds. There may be areas within the ANWR where summer activities would be acceptable, depending upon the numbers and species of wildlife likely to be encountered. As with a winter helicopter operation, surveys using the Vibroseis technique would be infeasible due to the weight of equipment.

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CHAPTER I

PURPOSE AND NEED FOR ACTION

On December 2, 1980, during the second session of the Ninety-sixth Congress, the Alaska National Interest Lands Conservation Act of 1980, 16 U.S.C. 3101-3233 (ANILCA), was enacted. Section 1002 of the act (appendix D) provides for a comprehensive and continuing inventory and assessment of the fish and wildlife resources of the coastal plain of the Arctic National Wildlife Refuge (ANWR) and an analysis of the impacts of oil and gas exploration, development, and production. It also authorizes exploratory activities within the coastal plain in a manner that avoids significant adverse effects on the fish and wildlife and other resources. The resource assessment is to culminate in the submission of a report to Congress not earlier than 5 years after the enactment of the act and not later than 5 years and 9 months after such date. This report to Congress will include a recommendation on the desirability of future exploration, development, and production of oil and gas resources and an evaluation of the adverse effects of further oil and gas activities on the known fish and wildlife, their habitats, and other resources of the coastal plain. ANILCA also requires that, by regulation, initial guidelines governing the carrying out of exploratory activities be established and accompanied by an environmental impact statement (EIS) on exploratory activities.

The coastal plain of ANWR has been identified by the U.S. Geological Survey (USGS) and the oil and gas industry as highly prospective for significant accumulations of oil and gas. Exploration activities to be conducted on ANWR will be designed to identify those areas having oil and gas production potential and to estimate the volume of potential resources. The results of these exploratory activities should provide valuable information for evaluating how the potential oil and gas resources of ANWR relate to the national need for domestic sources of energy.

A stated purpose of ANILCA (Section 101(b)) is "to provide for the maintenance of sound populations of, and habitat for, wildlife species of inestimable value to the citizens of Alaska and the Nation, including those species dependent on vast relatively undeveloped areas." Prior to approving any exploration plans, Section 1002(c) requires an ongoing baseline fish and wildlife resource study of the ANWR coastal plain, with special emphasis on caribou, wolves, wolverines, brown bears, polar bears, muskoxen, and migratory waterfowl. The study is to assess fish and wildlife populations by size, range, and distribution and to determine the extent, location, and carrying capacities of their habitats. The potential impacts of oil and gas exploration and development and the impacts of human activity on fish, wildlife, their habitats, and the environment are to be addressed. Potential effects of oil and gas exploration on Alaskan Native culture and lifestyle (including subsistence) are also to be analyzed. An initial report on the baseline study was published in April 1982. The results of the study will be updated, as appropriate, as new information is obtained.

This EIS, the FWS Baseline Study, and other environmental analyses provide the background data upon which draft regulations have been developed to ensure that no significant adverse effects occur to fish and wildlife populations, their habitats, or the environment of ANWR. These draft regulations take into

consideration a variety of geophysical exploratory techniques and provide for the FWS to impose supplementary stipulations as necessary and appropriate to ensure that all activities are carried out in a manner avoiding significant adverse effects.

Exploration, development, production, and transportation of petroleum is occurring in nearby oil fields on the North Slope of Alaska. The Prudhoe Bay unit and the Kuparuk River unit, west of Prudhoe Bay, are currently in production. The Milne Point unit, located between and slightly north of Prudhoe and Kuparuk, is scheduled to go into production in 1985. The Duck Island unit, east and north of the Prudhoe Bay unit, will begin production in 1987. Several areas are currently being explored--the Point Thomson unit, just west of the ANWR study area along the coast, and the Mikkelson Bay unit, between Prudhoe Bay and Point Thomson. Farther west, the outlying parts of the Kuparuk River unit are still being delineated. The Colville River Delta also contains leased lands, and exploration is beginning there. The National Petroleum Reserve-Alaska (NPR-A), extending from the Colville River west to the Chukchi Sea, has been preliminarily explored under direction of the USGS. Oil exploration is also being conducted off the Mackenzie River Delta in Canada, with development expected to begin in 10 years.

It is not yet possible to predict whether commercial quantities of oil or gas will be found in the ANWR study area or where reservoirs might be located. However, Section 1002(h) of the act requires that the report to Congress identify those areas that have oil and gas production potential; estimate the volume of oil and gas concerned; describe fish and wildlife, their habitats, and other areas; evaluate adverse effects of further exploration and the development and production of oil and gas resources; describe how such oil and gas resources may be transported; evaluate how such oil and gas relates to the national need for additional domestic sources of oil and gas; and contain the Secretary's recommendations with respect to whether further exploration for, and the development and production of oil and gas within the coastal plain should be permitted and, if so, what additional legal authority is necessary to ensure that adverse effects of such activities on fish and wildlife, their habitats, and other resources are avoided or minimized. After receipt of the coastal plain resource assessment report, Congress should have the information necessary to determine whether further oil and gas resource exploitation activities are warranted on ANWR. Section 1003 of ANILCA specifically prohibits leasing or other development leading to production of oil and gas until authorized by an act of Congress.

Section 1317 of the act further requires that the Secretary review within 5 years all lands within units of the National Wildlife Refuge System in Alaska not already designated as Wilderness for their suitability.

CHAPTER II

ALTERNATIVES

Within the broad spectrum of alternative regulations which could be developed, three regulatory strategies have been identified. These alternative approaches involve providing detailed, moderate, and general guidance to applicants.

Basic to developing any regulatory approach are the stipulations of the act. The regulations establishing guidelines required by section 1002(d) of ANILCA are to be based on the results of the baseline study required under subsection (c) and such other information as may be available to the Secretary of the Interior. The act further requires that the guidelines include such prohibitions, restrictions, and conditions on the carrying out of exploratory activities as the Secretary deems necessary or appropriate to ensure that exploratory activities do not significantly adversely affect the fish and wildlife, their habitat, or the environment, including but not limited to:

- A prohibition on the carrying out of exploratory activity during caribou calving and immediate postcalving seasons or during any other period in which human activity may have adverse effects;

- Temporary or permanent closing of appropriate areas to such activity;

- Specification of the support facilities, equipment, and related manpower that is appropriate in connection with exploratory activity; and

- Requirements that exploratory activities be coordinated in such a manner as to avoid unnecessary duplication.

Following are brief descriptions and evaluations of alternatives. Alternatives 1 and 2 constitute detailed and general levels of regulatory guidance and control. Alternative 3, representing a moderate or intermediate degree of regulation, is the proposed action. It is also the preferred alternative and includes a detailed description and evaluation of state-of-the-art methods for accomplishing surface geological and geophysical exploration on the coastal plain. Alternative 4 describes the consequences of no action, which would be the failure to establish guidelines.

ALTERNATIVE 1. REGULATIONS AUTHORIZING GOVERNMENT-PRESCRIBED OPERATIONS

The objective of this alternative would be to assure the prevention of significant adverse environmental impacts by providing a high degree of Government control over all aspects of exploratory activities through development of regulations which would either (1) contain extremely detailed guidance with regard to every aspect of an applicant's actions, or (2) empower the Regional Director, FWS, to provide very specific guidance and control through the development of detailed operational stipulations.

The development of either of these regulatory subalternatives would require that the study area be broken down geographically into relatively small areas based on detailed habitat sensitivity and wildlife use data. The guidance would specify the season and duration of activity, the surface geophysical method(s) to be applied, and the technique(s) for accomplishing the work; and establish detailed standards and criteria for environmental protection as the basis for the Secretary's evaluation and approval of exploration plans.

Although sufficient biological data presently exist on which to base adequate guidance and control to assure prevention of significant adverse impacts, detailed site-specific information on the refuge has not been collected and evaluated to support development of criteria to control activities on a very site-specific basis. To attempt to do so at this time could result in inconsistent control standards and could prevent the flexibility to quickly alter exploration criteria as the need becomes evident through field experience. On the other hand, this alternative could assure a higher degree of protection for the refuge's resources, particularly if the regulations were structured to give the Regional Director the power to direct field operations. Because of uncertainties due to the present lack of detailed, site-specific biological data, more areas might be excluded from exploration as a precautionary measure. While this may result in fewer environmental impacts than might be expected under alternatives 2 or 3, it would likely preclude an adequate assessment of the coastal plain and result in insufficient data regarding oil and gas resources.

Detailed regulatory guidance could prevent the flexibility required to avoid animal concentrations, which may vary widely in their locations seasonally and from year to year. This is particularly true of caribou and, to a lesser extent, muskoxen and migrating waterbirds. Geophysical activity which may be entirely acceptable during certain seasons or in particular locations during one year may have totally unacceptable impacts another year as a result of these unpredictable shifts in animal concentrations.

This problem would be lessened to some extent under the second subalternative because the regulations would authorize the Regional Director to tell applicants how, when, and where they could operate, thus increasing the flexibility of controls. This would not prevent the possible development and imposition of inconsistent control standards. But it would not provide applicants a sound or uniform basis upon which to formulate exploration plans.

Related to either subalternative would be the increased Government costs and management controls needed for the higher levels of personnel and funding which this alternative would require.

ALTERNATIVE 2. REGULATIONS AUTHORIZING APPLICANT-DEFINED OPERATIONS

This alternative would promulgate regulations that provide only the most minimal guidance to ensure environmental protection within broad standards of Section 1002(d)(1) of ANILCA, with the concept of allowing the applicant to tell the Government how and when operations would be conducted and how the standards of the act would be satisfied. Section 1002(e) requires that an exploration plan set forth such information as the Secretary may require to determine its consistency with the regulations. Regulations developed for this

alternative would state in very minimal and general terms or objectives the applicable prohibitions, restrictions, or conditions for the applicant, and would place the burden on the applicant to assure compliance with the statutory standard of no significant adverse effects. This would allow an applicant to have maximum discretion and flexibility in designing plans and assuring conformance. A problem inherent in this approach is that the regulations would not give an applicant any guidance as to what constitutes significant adverse effects. Because there would be no specific common basis for development of exploration plans, there could be a great amount of variance in the types of plans submitted for Secretary's approval. Judgments involved in plan approval would be based on more subjective evaluations of probable impacts and their significance. Because this alternative would provide for less control over finding plans consistent with the regulations, more plans would probably be approved than would be under alternatives 1 and 3.

Without specific limitations or performance standards against which to measure impacts, and given the fact that more plans would probably be approved to permit exploration, there would be a greater likelihood of significant adverse impacts due to unanticipated results of a particular method or technique. In an attempt to further ensure no significant adverse impacts, full-time onsite FWS monitors with authority to halt or modify an operation would have to be present on each seismic crew for the duration of the activities proposed by a plan. Enforcement authority of these FWS monitors would have to be respected at the scene in an effort to preclude any immediate significant adverse impact. Because of the possible variety of plans that would be submitted for approval, it is likely that those approved could result in a greater variety of impacts than could be expected to occur if more specific guidance were provided. This would increase the amount of onsite FWS monitoring required. The greater the reliance on on-the-spot monitoring rather than on initial avoidance, the greater the potential for impacts to occur before enforcement action can be taken.

Although operations permitted under this regulatory alternative would result in essentially the same types of impacts as those under the proposed action, the numbers and magnitude of impacts could be greater. For example, the proposed regulations delineate special use areas to protect other wildlife in addition to caribou that would be avoided either entirely or during certain time frames. No such areas would be defined by regulations if this alternative is selected. Disturbances to sensitive land cover types and archeological resources are more likely to occur without guidance on restricted entry, adequate protective cover, blading and compaction, and solid waste disposal. Fish and wildlife disturbance is more likely to occur in the absence of specific guidance as to the use of explosives, wildlife harrassment, vehicle operation, and delineation of special muskoxen calving areas and brown bear denning areas, etc. There is also a much greater potential for cumulative impacts under this regulatory option.

ALTERNATIVE 3. THE REGULATIONS AS PROPOSED (PROPOSED ACTION)

The proposed regulations contained in this EIS (appendix A) reflect a moderate level of guidance and control. They are designed to provide the limitations and environmental safeguards necessary to prevent significant adverse impacts to fish, wildlife, and the environment while permitting sufficient flexibility for effective and efficient control and management of the exploration program. They permit industry to choose among geologic and geophysical methods which will satisfy the requirements of the safeguards, and impose the burden on

the applicant to show that their proposed methods satisfy the environmental safeguards of the regulations.

Various geological and geophysical exploratory techniques are analyzed in this EIS. It was determined that geophysical seismic surveys would best provide the level and accuracy of data required. However, because magnetic and gravity geophysical methods do not require exploratory drilling, they have been included as a supplement to the seismic method. Given the character of the magnetic and gravity methods, the design of the proposed regulations to include them to be permitted is believed consistent with the act. Geological and nonseismic geophysical techniques are evaluated, since they would contribute to the efficiency and economy of seismic operations by providing reconnaissance level information which could be useful in planning the seismic studies and in interpreting the data from these studies.

Geological Exploration

Subsurface Geological Exploration

Of the two geological techniques--subsurface and surface--subsurface exploration was eliminated from consideration because the required drilling of deep bore holes is explicitly prohibited by ANILCA.

Surface Geological Exploration

In the Arctic National Wildlife Refuge (ANWR), surface geologic studies and geologic mapping can provide important information for assessing the petroleum potential of the coastal plain. A good understanding of the stratigraphic sequence of sedimentary rocks exposed in the mountains south of the coastal plain is important in that, during a subsequent seismic program, these strata, by extrapolation, can be projected northward and correlated into the subsurface seismic profiles. A number of geologic studies, reports, and maps have already been done. Mapping of the area was compiled by Beikman (1980) and numerous reports are listed in bibliographies by Maher and Trollman (1970) and Emmel (1982). It is anticipated, however, that some additional surface geologic exploration may be necessary to gather additional data for the resource evaluation mandated by ANILCA.

Surface geological exploration may be preceded by low-level aerial reconnaissance using small fixed-wing aircraft. The aerial survey would be followed by helicopter deployment of one or more field parties, each comprised of four to five geologists who would perform surface field studies. Although the work might be accomplished in one field season, two or more seasons could be required, depending on weather, animal movements, and any special-use restrictions. Surface geological mapping and studies have been conducted on the Arctic Slope of Alaska, including the ANWR, for many years without significant environmental impact. If such activity is conducted under the ANILCA-mandated resource evaluation, it will be restricted by the proposed regulations, and no significant environmental disturbance is anticipated.

Although this technique would probably result in little or no environmental impact, the quality and quantity of data obtained could only be used to supplement geophysical exploration and is not in itself capable of providing the comprehensive

information necessary to locate and estimate the potential oil and gas resources of the ANWR coastal plain study area.

Geophysical Exploration

There are three basic types of geophysical surveys which can be used effectively in the study area--magnetic, gravity, and seismic. Magnetic and gravity surveys provide reconnaissance-level data that assist in delineating the extent and major structural features of sedimentary basins. Because they produce very broad, general information, they cannot be wholly substituted for seismic techniques but are used primarily to provide an overview of hydrocarbon potential upon which a more efficient seismic exploration program can be based. Seismic surveys provide the fine, small-scale stratigraphic-structural details necessary to delineate the location of potential hydrocarbon traps that are needed to define the best drilling program for assessment of oil and gas reservoir potential.

A general discussion of the magnetic, gravity, and seismic geophysical methods follows. A detailed discussion of seismic methods using various combinations of techniques and equipment, during different seasons of the year, is included.

Magnetic Surveys

A magnetic survey can be done wholly by aircraft using airborne magnetometers. Since sedimentary rocks are practically nonmagnetic as compared to the deeper "basement" rocks, magnetic measurements provide patterns of magnetic anomalies from which the spatial extent and thickness of sedimentary deposits can be inferred. Such a survey would likely be accomplished by flights at about 1,500 feet above the ground in a grid pattern of about 3 miles. This would yield approximately 2,000 linear miles of magnetic profiles on the ANWR study area. The survey would require about 7 days' flying time, although up to four times that long could be required because of weather delays. Environmental impacts from this type of survey would be negligible if limited to seasons of the year when presence of wildlife is minimal or by maintaining a specific altitude that would prevent disturbance. There would be some short-term disturbance to molting or migrating waterfowl. Information obtained from magnetic surveys would be general, and would be used to supplement seismic surveys.

Gravity Surveys

Gravity surveys use both ground and airborne equipment, but they require that gravity meter readings be taken on the ground. Helicopter supported gravity surveys can be made utilizing an inertial guidance system, making ground surveying unnecessary. The survey stations are usually in the form of grids ranging from ½-to 3-mile intervals. The helicopter lands at each preselected station and the gravity-meter reading is taken on the ground. Environmental impact is limited to the sound and disturbance of the helicopter. Since it must land at frequent intervals, there is considerably more potential for disturbance to any nearby wildlife than with the magnetic survey.

If done in time so that data could be processed and made available prior to seismic program planning, such data could assist industry in the optimal placement

of seismic lines, and possibly reduce the number of seismic lines required. A gravity survey could also provide information to augment seismic data and to help delineate geologic structures more accurately .

Any airborne gravity surveys proposed would likely be undertaken during late fall or early winter (September, mid-October). Gravity surveys could also be accomplished as an adjunct to a winter seismic operation using ground vehicles.

Seismic Surveys

In recognition of the fact that industry will probably submit plans which include some type of seismic exploration, four seismic methods have been outlined and evaluated:

Winter access by ground vehicle
Winter access by helicopter
Summer access by ground vehicle
Summer access by helicopter

Within each seismic discussion is a further breakdown and evaluation of the three seismic techniques--mechanical (Vibroseis), conventional, and air shot (Poulter). Of these, winter access by helicopter would be least damaging, Summer access by ground vehicle would be the most damaging.

Seismic exploration is based on the principle that rocks and strata of differing physical properties within geologic formations alter the time of travel and path of pulses generated by mechanical energy or by surface or subsurface explosions. The differential traveltime of energy pulses reflected or refracted from underlying strata is recorded by arrays of geophones lying on the ground, which, in turn, transmit the signals for recording on magnetic tape. The magnetic tape is then electronically processed for analysis. Seismic surveys provide fine, small-scale stratigraphic and structural details of subsurface geology and constitute the main method by which detailed delineation of subsurface strata and structures of sedimentary basins are obtained.

The three most commonly used seismic survey techniques are mechanical (Vibroseis), conventional, and air shot (Poulter). Similarities or differences among the techniques and the resulting impacts depend largely on the season of the year in which they are conducted and the type of equipment and logistical support required. In each instance, a typical operation would follow a survey line that would transect the area being studied. This survey line would be part of a grid consisting of parallel lines, generally spaced at intervals of 2 to 10 miles, which would intersect and be roughly perpendicular to a second series of lines spaced at similar intervals. Energy would be induced into the earth along these lines at intervals (or multiples) of 220 feet. The reflected energy would be recorded by groups of geophones placed in an array about the energy source.

Winter Access by Ground Vehicle

Each of the three seismic techniques could be undertaken during the winter using ground vehicles and cat-trains.

Mechanical Survey (Vibroseis)

"Vibroseis" (a trademark of Continental Oil Company) has been the most commonly used technique for winter seismic surveys in northern Alaska in recent years. This technique is operated entirely on the surface of either land or ice and generates energy into the subsurface by vibrating the surface, over a range of frequencies and durations (less than 20 seconds) depending on conditions of the area, in a pattern dependent upon prevailing noise conditions and energy requirements. A typical mechanical operation uses three or four vehicles, each equipped with a large steel plate. The plates are lowered to the ground, and the weight of each vehicle is applied for a total applied weight of 40,0000-60,000 pounds. The plates are vibrated in unison for the specified length of time at a range of frequencies. The vibrator vehicles then move forward in tandem and the process is repeated. Seismic impluses are recorded via an array of geophones spread on the ground and connected to instruments in a recording vehicle. The mechanical system is unique in that it is the only system that can control the pulse frequency and duration, making it possible to match energy transmission characteristics for best signal returns. A disadvantage of the system is its bulk and weight, making it adaptable only to heavy-duty land vehicles. It cannot be used in mountainous terrain or unfrozen marshes, bogs, or tundra, nor is it adaptable for use in open water (shipboard surveys).

The mechanical method is conducted during the winter using ground vehicles (Nodwells and Bombardiers) accompanied by a supporting mobile camp (cat-train) of up to 50 personnel. The camp consists of up to 20 trailer units mounted on sleighs or flexible tracks. Generally, five trailers are pulled in an individual "train" by a crawler tractor, such as a D-7, and the entire camp is moved daily or every other day to remain near the activity of the seismic crews. Air support is required to transport personnel, food, fuel, explosives, etc. Generally two to five flights a week are required, but as many as two or three flights a day could be necessary. Temporary airstrips are established on large lakes or long gravel bars. Water is generally obtained from nearby lakes. Camps utilize approximately 500 gallons of water per day. If lakes are not convenient, water can be obtained by melting snow with a snow melter. Snow melters, however, require fuel to operate and this, in turn, necessitates additional aircraft support flights.

Lists of typical equipment and descriptions of a typical mechanical operation follow:

Equipment

Twelve living trailers, including shops and powerplants, sled or track-mounted. Weights vary, but none should exceed ground pressure of tractors used for towing.

One camp utility vehicle. Nodwell FN-110 or similar, gross weight 42,000 lb, ground pressure 5 to 6 p.s.i., or Nodwell FN-60 or similar, gross weight 30,000 lb, ground pressure 5 p.s.i.

Three fuel sleds, weight estimated 36,000 lb, ground pressure estimated 5 p.s.i.

One or two utility trailers

Two auxiliary trailers (survival camp). Self-contained living, powerplant, and shop unit.

Five tractors (usually D-7)--the primary functions of tractors are towing of the camp trailer strings, clearing deep or drifted snow and ice along the seismic line, airstrip preparation, and recovery of disabled vehicles.

Camp configuration and moving procedures

The camp would typically consist of three strings of four trailers each, plus a string comprised of the fuel and utility trailers, each string towed by a single tractor, and an auxiliary string. Living-trailer strings are usually parked parallel, 50 to 100 feet apart, with the fuel string parked several hundred feet away. The camp would ideally keep pace with the seismic operation but, as a practical matter, might remain at a location for 2 to 3 days to take advantage of a favorable airstrip site, or remain near a line intersection where the recording crew would be within a reasonable distance for several days. The camp would seldom be more than 10 miles from the spread or seismic activity. During moves, the camp strings would usually follow the recording crew in a single line along the survey line but could deviate the survey line for as much as 2 miles to avoid steep or rough terrain or the spread itself. The auxiliary string would often move independently in advance of the main camp in order to locate and prepare temporary airstrips for resupply flights.

Aircraft operations

Winter operations would require aircraft support to resupply the equipment with fuel and to resupply other necessary items for personnel. Twin turbine, medium-sized Stol-type aircraft (Dehavilland Twin Otter, Short Skyvan, or similar) are commonly used. These aircraft require a reasonably smooth runway of about 1,500 feet (longer runways may be required if conditions are not optimal). In winter, desirable onshore sites are frozen lake surfaces or straight stretches of smooth river ice. Two to three fuel resupply flights a week are required, and flights for personnel changes and other supplies would be needed twice a week.

Operating configurations and procedures

Operating configuration and procedures for a mechanical survey would vary, depending on data-collection parameters, but would typically be as follows: A "geophone spread" length would be 2 to 5 miles along a single line. The operation would move forward, leapfrog fashion, with the cables and geophones being picked up behind the spread, carried forward, and laid out in advance of the spread. Three or four vibrators would be arranged in line at the center of the spread, 40 to 50 feet apart, at a source point. Source points would be located at 220 to 440-foot intervals (or multiples thereof). Vibrators would be activated in unison for up to 20 seconds, moved forward in tandem a distance of 18 to 24 feet, and activated again. This process would be repeated 6 to 24 times at each source point.

Traffic would generally be restricted to an area 200 to 300 feet either side of the line. Multiple passes would be made over each line by a variety of support vehicles during the survey process. Surveyors would be operating up to 10 miles ahead of the recording crew and would also be operating along parallel or intersecting lines that would be "shot" next in the sequence. Each mechanical survey operation would average 3-4 miles per day.

Vibration equipment and vehicles

In addition to the camp and support vehicles, a winter vibration survey would also require the following specialized equipment:

Four vibrator units, track or wheel mounted. Gross weight 56,000 lb (tracks), 45,000 lb (wheels), 35,000 lb on the pad; ground pressure 5.4 p.s.i. (tracks), 5 p.s.i. (wheels), 10 p.s.i. on the pad.

One recorder vehicle, Nodwell FN-110, gross weight 45,000 lb, ground presure 5 p.s.i.

One vibrator tender. Similar size and weight to vibrator. Gross weight 45,000 lb, ground pressure 5 to 6 p.s.i.

One gravity survey vehicle, Bombardier or similar, if gravity data are to be collected.

The impacts attributable to a winter mechanical operation would result primarily from ground-surface disturbance by the heavy equipment required and disturbance to animal life caused by noise, human activity, and the use of equipment. The significance of these impacts would vary depending upon the condition of the ground (depth of frost, depth of snow cover, thickness of ice on streams or lakes), type of ground vegetation, topography, and the presence of animal life. Many, but not all, of these impacts can be avoided or minimized by appropriate mitigative measures. Mitigation is primarily related to precautionary or restrictive measures imposed and enforced through appropriate regulations. Details and analyses of impacts associated with winter mechanical operations are contained in chapter IV, "Environmental Consequences."

Conventional Survey (Subsurface Explosives)

Historically, the most used energy source for reflection seismic exploration is explosives detonated beneath the ground surface. Vehicle-mounted drilling rigs are used to drill a series of "shot holes," ranging from 50 to 400 feet deep and 3 to 4 inches in diameter, into which explosives are placed. The size of the charge and number of holes required per shot depends on local conditions. Normally, the amount of explosive ranges from 50 to 150 pounds per hole, in holes drilled along the shot line at a spacing (or multiple) of 220 feet. The holes are backfilled with drill cuttings, with the excess cuttings raked away from the holes and spread smoothly to prevent smothering vegetation. Energy waves generated by the explosions and differentially reflected back to the surface from the subsurface rock strata would be received by a continuous string of geophones similar to the mechanical method.

Logistically, the number of people, vehicles, and equipment required for a winter conventional seismic survey would be similar to the requirements of a winter mechanical operation. Major differences would be the requirement for two to three additional flights per week for resupply of explosives, and the use of four to five track-mounted drills, a preloader vehicle, and a shooter vehicle instead of the vibration equipment.

Conventional equipment and vehicles

Four or five track-mounted drills, FN-110 or equivalent, gross weight 42,000 lb, ground pressure 5.5 p.s.i.

One preloader vehicle, FN-110 or equivalent, gross weight 42,000 lb.

One "shooter" vehicle, Bombardier or FN-60, gross weight 42,000 lb.

Although the conventional below ground explosive technique introduces a more severe shock wave into the earth, impacts associated with a conventional survey conducted during the winter months would be almost identical to those associated with a vibration survey. Since the holes drilled for placement of the explosives would be backfilled, evidence of their existence would disappear during the first summer season. Below-ground detonation of conventional survey explosives is not known to significantly impact any wildlife species when the holes have been properly filled. However, to assure that aquatic life is not disturbed, operators would have to adhere to prescribed minimum distances from fish streams and lakes.

Air-Shot (Poulter) Survey (Surface Explosives)

The air-shot, or Poulter, technique also employs explosives as an energy source, but detonation occurs on or above the ground surface. A winter Poulter survey, if restricted to use of ground vehicles, would be conducted similarly to winter conventional or mechanical surveys. Vehicles and personnel required to operate vibrator units or drills would not be required. This method of exploration is most commonly conducted with helicopter support rather than by winter cat-train.

Operating configuration and procedures

The general layout of the geophone spread would be similar to those for a vibration or conventional surface vehicle operation. Total length of the spread would be up to 5 miles. A total explosive charge of 30 to 60 pounds would be used, divided into 2- to 5-pound packages arrayed about the source point in various patterns. The pattern and size of the charge most effective for a particular area would be determined by field conditions at the outset of the program. The explosives would be attached to stakes approximately 3 feet above ground, or laid directly on the ground if there were sufficient snow cover to prevent disturbance of the underlying vegetation. After detonation, cables and geophones would be picked up behind the spread and shuttled forward to the next source point (spaced at intervals of 220 feet or multiples thereof). Progress along the line could be as much as 5 miles per day, but more likely would average 3 to 4 miles per day.

With the absence of drilling rigs or vibrators and the reduced numbers of surface vehicles and personnel, the nondetonation-related operational impacts of a Poulter survey would be less than with a mechanical vibration or conventional survey. Impacts to soil and vegetation from surface explosions would be minimal if snow cover were adequate, and could be further reduced or largely eliminated by placing the explosives on stakes. However, impacts associated with the ground vehicles and crew support facilities would still exist. Also, noise impacts from using above-ground explosions as an energy source would be much greater than those from the other techniques. The effect of noise impact would largely be

determined by the proximity to animals, the reaction of various species to the explosions, and the degree of attenuation by wind, which commonly blows across the coastal plain. During the winter, the relative scarcity of animals in portions of the refuge could make this technique preferable to subsurface explosive or vibration surveys because it requires fewer vehicles and personnel.

Winter Access by Helicopter

Mechanical Survey (Vibroseis)

Due to the extremely heavy equipment required to transmit vibrated energy into the subsurface (in excess of 40,000 lbs. per unit) and the number of vibrating units required (three or four machines simultaneously transmitting energy into the ground), a mechanical survey is not a feasible operation if transportation is limited to helicopters.

Conventional Survey (Subsurface Explosives)

Although a helicopter-transported conventional survey has not been undertaken on the North Slope, it could possibly be accomplished in early and/or late winter. Such an operation would require a camp located within reasonable flight time from the survey areas. Much of the ANWR coastal plain could be reached from existing airstrips if suitable arrangements could be made for their use.

The helicopter-transported operation would be essentially identical to a conventional surface survey operation except that the drills, cables, geophones, and all supplies would be transported along the lines by helicopter instead of by surface vehicles. The helicopter would make from one to as many as three or four trips to move a drill to each new shothole location. Drill size would be determined by the depth of holes required for shot placement. Large drills would have to be disassembled for moving in several components. Fuel demand for the drills and helicopter would necessitate frequent flights between the recording crew and the camp. Fuel requirements for this type of operation would require continuous daily resupply, involving up to three fixed-wing or five heavy-duty helicopter flights per day from the supply point to the operating camp.

Required equipment and aircraft

Two or three helicopters with 2,000-pound load capacity or two larger helicoptors, such as Bell 205 or similar.

Four or five drills. Some large drills can be broken down into three or more components, including air compressor, mounted on a subframe. The assembled unit would exert ground pressure of abut 2 p.s.i. on four circular pads.

Four to five helicopter baskets for drill rods, bits, etc.

One recorder "doghouse," 600 to 1,250 lb.

Noise impacts would be greater than those for a ground vehicle operation inasmuch as extensive use of helicopters would cause noise to affect a greater area than would surface vehicles. However, in selected areas there would be relatively

few animals present during early or late winter; thus, disturbance should affect relatively few individuals. Animals in the impact area during a winter survey would, however, be subject to disturbance at a time of year when many are in their poorest condition and least able to cope with unnatural stress factors. Another consideration is that the period during which the operations could be practicably or safely conducted is short, probably not more than 2 months (mid-March to mid-May). In the fall, a helicopter-supported operation would be generally limited to September and early October. Darkness, cold, wind, snowstorms, and other hazards to extensive helicopter use could preclude winter operations much later than mid-October or earlier than mid-March.

Air-Shot (Poulter) Survey (Surface Explosives)

As with conventional survey techniques, it is possible to conduct an early and/or a late winter seismic program utilizing a helicopter-transported air-shot (Poulter) operation. Again, the major difference from the conventional operation is that drill rigs would not be required, nor would the large helicopters necessary to transport the drill rigs. However, several smaller helicopters would still be required to ferry personnel and equipment. Properly conducted, this operation would result in little or no ground-surface disturbance. In addition to helicopters, a major source of noise would be the above-ground detonation of explosives required to generate shock waves into the earth. Again, in selected areas supporting very little wildlife, the impact of sound would be negligible; however, careful consideration would have to be given to the effect on any animals that were in the area. As with a winter conventional survey, the period of effective use of helicopters in the fall would be limited to September and possibly early October. The practicable period prior to breakup probably would not be more than 2 months at the most, generally from mid-March to mid-May. Areas where muskoxen calve in April and May would have to be avoided.

Summer Access by Ground Vehicle

Summer seismic exploration utilizing ground vehicles has the potential for unavoidable significant impacts, especially vehicle-caused vegetation crushing and soil compaction and erosion, and visual degradation which would impact esthetic and wilderness values.

Summer Access by Helicopter

Mechanical Survey (Vibroseis)

As described earlier, a mechanical survey utilizes heavy equipment impracticable for transportation by helicopters and, thus, is not a feasible technique.

Conventional Survey (Subsurface Explosives)

A helicopter-supported operation could be conducted in early or late winter; however, it could more feasibly be accomplished during the summer. The equipment and personnel requirements would be essentially identical. In some places, camps could be located at greater distances from the survey areas than could be safely done during a winter operation.

Although the impacts to the soils and vegetation would be reduced by a helicopter-supported operation, the noise generated by the drilling rigs and the noise from the helicopters would probably equal or exceed that of a surface operation. Wildlife could be disturbed over a considerably wider expanse by helicopters than they would by ground vehicles. The explosive generation of impulses would be similar with either method. Although the sound of the explosives may not be perceived by the human ear at distances greater than 50 feet from a given shothole, it cannot be assumed that the same is true for fish and wildlife, whose senses are commonly more acute and whose behavior could be affected by such sensory input. Following the period of waterfowl breeding, nesting, and brooding, and of caribou calving, the potential impact of helicopter-supported seismic operations would be greatly reduced, although disturbance to mammals and migrating birds would still be a consideration in some areas until they have departed for the winter. Selectively, however, there are portions of the refuge where summer helicopter operations would likely not have significant impact on wildlife.

Air-Shot (Poulter) Survey (Surface Explosives)

A helicopter air-shot operation restricted to summer months would be similar to a helicopter-supported conventional survey, except that drills and baskets would not be required, and in comparison to a conventional survey, the number of personnel would be reduced by about one-fourth. Helicopter traffic along the lines would be reduced by about one-half, and smaller helicopters could possibly be used. Resupply and movement of other equipment would be similar to that required for a helicopter-supported conventional survey.

Required equipment and aircraft (summer Poulter survey)

Two or three helicopters with payload of 1,000 to 1,500 lb (Bell 206 or larger).

One recorder "doghouse," 600 to 1,500 lb.

Sequential open-air detonation of approximately 25 to 50 explosive charges per mile would generate a substantial amount of noise and shockwave energy that would carry for distances up to several miles from the detonation point. Although many species exposed to this technique in the past have been observed to be disturbed only momentarily and, in fact, have reoccupied areas adjacent to Poulter shot lines within a few hours following detonation, there is little scientific evidence as to what extent fish and wildlife resources may suffer from this type of disturbance.

As opposed to winter, in the summer extensive areas of the ANWR coastal plain are intensively used by large numbers of fish and wildlife. During this season, most species are engaged in reproductive activity and are at the height of their behavioral sensitivity. The noise and shockwaves associated with Poulter survey detonations would potentially disturb a large number of species and any associated human subsistence and recreational activities. However, impacts could be substantially mitigated by restricting operations to areas devoid of significant wildlife concentrations. Inasmuch as these areas are constantly changing throughout the summer season, many areas would have to be excluded from exploratory activities for relatively short periods of time.

ALTERNATIVE 4. NO ACTION

The No Action alternative is defined as the decision not to establish guidelines by regulation for oil and gas exploration on the ANWR coastal plain. It would result in a continuation of the fish and wildlife management programs currently being practiced on the ANWR coastal plain as a part of the National Wildlife Refuge System. To the extent that significant oil and gas resources may underlie the study area, the Nation would hold these energy resources in reserve until a decision is made that their value outweighs the value of maintaining the pristine wilderness character of the refuge.

A decision of "No Action" could result if (1) all exploration techniques were deemed to result in significant adverse impacts that could not be mitigated in any way, or (2) the Congress specifically repealed the provisions of ANILCA that require guidelines to be promulgated.

CHAPTER III

AFFECTED ENVIRONMENT

The study area (fig. III-1) of the ANWR proposed for oil and gas exploration is an irregularly shaped portion of the northern coastal plain and foothills lying between 142° W. and 146° W. and north of 69°34' N., covering approximately 1.4 million acres. It is bordered by the Brooks Range on the south and by the Beaufort Sea on the north. The Aichilik and Canning Rivers provide the east and west boundaries, respectively. The two permanent settlements within the ANWR boundary are the village of Kaktovik, with a 1980 population of 165, mostly Inupiat Eskimo (18 non-Native); and the U.S. Air Force Distant Early Warning (DEWLine) site, occupied by approximately 70 personnel. Both of these settlements are on Barter Island, immediately off the north coast about midpoint along the coast north of the coastal plain study area.

PHYSICAL ENVIRONMENT

Physiography

Two of the major physiographic provinces of North America extend into northern Alaska--the Interior Plains and the Rocky Mountain System. The Arctic Coastal Plain is the only portion of the Interior Plains in Alaska, whereas the Brooks Range and Arctic Foothills represent the northernmost extension of the Rocky Mountain System (Wahrhaftig, 1965; fig. III-2). The entire area lies north of the Arctic Circle.

The 600-foot contour is generally considered to represent the break separating the Arctic Foothills from the Arctic Coastal Plain, although this distinction is less apparent in the eastern sections. Wahrhaftig (1965) divides the Arctic Coastal Plain province into the flat, lake-dotted Teshekpuk Section to the west and the gently undulating White Hills section to the east. The ANWR study area lies entirely within the White Hills section, and except for a few small areas of the flat coastal plain, most of the terrain is rolling and merges gradually to the south with the Arctic Foothills that comprise a large portion of the total study area.

Oil and Gas Resources

The U.S. Geological Survey (USGS) has published an appraisal of the oil and gas resources for the Arctic National Wildlife Refuge (Mast and others, 1980). The area assessed was the coastal plain; all of the petroleum potential in the refuge is thought to be in that area. The selected ANWR study area includes a major portion of these potential oil and gas resources, but the exclusion of Native village lands and the area east of the Aichilik River removes some of the lands having potential. The USGS estimates the ANWR study area to contain 90 percent of the oil and gas resource potential previously estimated for the entire refuge in 1980. Estimates by Mast and others (1980) for the refuge at the 95-percent level, the 5-percent level, and the mean are as follows:

Estimates of undiscovered in-place oil and gas resources

(Mast and others, 1980)

	95%	5%	Mean
Oil resources (Billions of barrels)	0.16	17.03	4.85
Gas resources (Trillions of cubic feet)	1.44	33.93	11.90

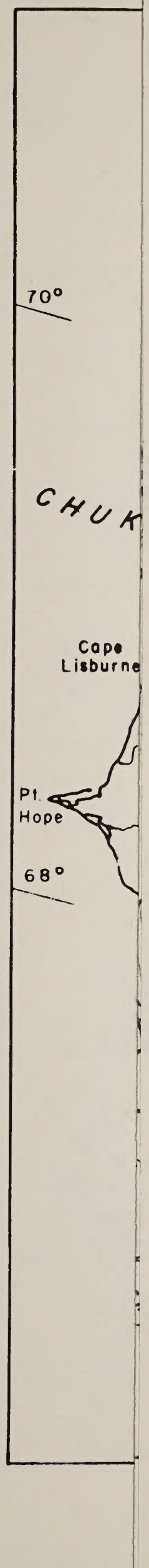
The resource estimates in ANWR were made by using a play analysis method developed by the Office of Minerals Policy and Research Analysis, Department of the Interior, in cooperation with the USGS, for the assessment of resources in the National Petroleum Reserve-Alaska (White, 1979). The play approach divides the geological characteristics of each play into three categories: play-specific, prospect-specific, and reservoir-specific attributes. Geologists familiar with the local geology make subjective probability judgments for each of the three sets of geological characteristics. A Monte Carlo simulation of these judgments provides a probability distribution of the in-place resources for each play. A second Monte Carlo simulation of the play resource distributions provides an aggregation of all plays to give a probability distribution of the total in-place resources.

Estimates of the recoverable oil and gas were not made as part of the USGS appraisal of ANWR. However, the estimates for oil and gas recovery for National Petroleum Reserve-Alaska (NPR-A) have been published (U.S. Department of Interior, 1979) and may provide some approximate guidelines for recoveries in ANWR. In NPR-A the recoveries for the base case were 26 percent of the in-place oil and 27 percent of the in-place gas. However, recoveries in the ANWR could be entirely different and would depend on field size, reservoir rock quality and continuity, gas-oil ratio, gravity of oil, depth, and other factors which control the cost of producing oil and gas. The study area is located at the intersection of several major geologic trends and has the characteristics of both the Prudhoe Bay and Mackenzie Delta petroleum provinces. Because of the absence of subsurface data, the resource estimates have been made by projecting geology from the adjacent areas and using other producing areas as analogs. Although the ANWR coastal plain appears to be high in petroleum potential, there is a high level of uncertainty in the resource estimates.

Water Resources

Surface- and ground-water hydrology of the ANWR is dominated by the cold dry climate and permafrost. Streamflow essentially ceases during the long winter. Precipitation occurring as snow from September to May is stored in the snowpack until breakup, which is characterized by a dynamic flow period in late May and early June. Most of the annual runoff occurs in this brief 2- to 3-week breakup period.

No flow records have been collected on streams within the ANWR study area, but based on other records on the North Slope, mean annual runoff is estimated to be about 0.5 cubic foot per second per square mile. A reconnaissance


70°
CHUK
Cape
Lisburne
Pt.
Hope
68°

Estimates of undiscovered in-place oil and gas resources

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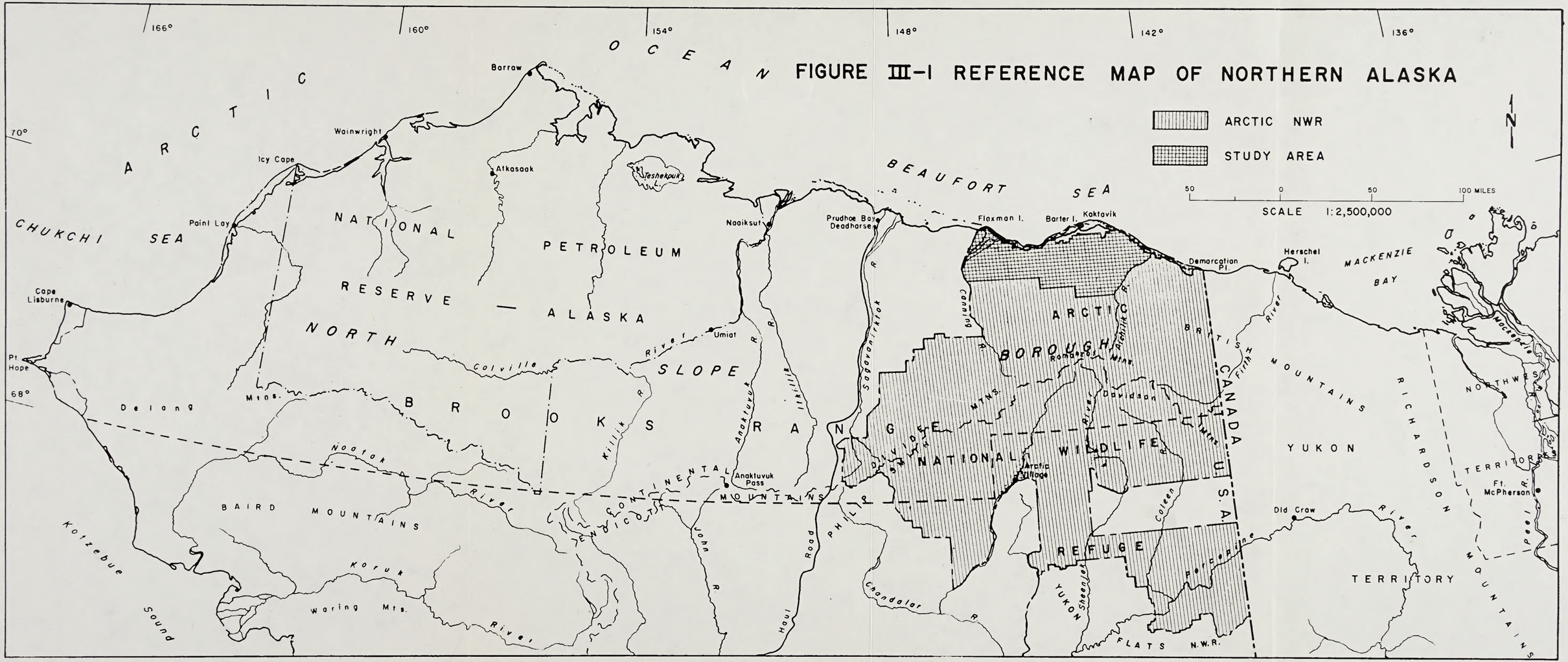
FIGURE III-1 REFERENCE MAP OF NORTHERN ALASKA
ARCTIC NWR
STUDY AREA
SCALE 1:2,500,000
50 0 50 100 MILES
N
166°
160°
154°
148°
142°
136°
70°
68°
ARCTIC OCEAN
CHUKCHI SEA
BEAUFORT SEA
Barrow
Wainwright
Icy Cape
Atkasook
Teshekpuk L.
Nuiqsut
Prudhoe Bay
Deadhorse
Flaxman I.
Barter I.
Kaktovik
Demarcation Pt.
Herschel I.
MACKENZIE BAY
Paint Lay
Cape Lisburne
Pt Hope
NATIONAL PETROLEUM RESERVE — ALASKA
NORTH SLOPE BOROUGH
ARCTIC NATIONAL WILDLIFE REFUGE
Umiat
Colville River
Delong Mts.
BROOKS RANGE
Killik R.
Anaktuvuk R.
Itkillik R.
Sagavanirktok R.
Canning R.
Hulahula R.
Romanzof Mtns.
Davidson Mtns.
Aichilik R.
Firth River
BRITISH MOUNTAINS
CANADA
U.S.A.
YUKON TERRITORY
NORTHWEST TERRITORIES
Mackenzie R.
Ft. McPherson
Old Crow
Porcupine R.
Coleen R.
Arctic Village
Anaktuvuk Pass
CONTINENTAL DIVIDE
ENDICOTT MOUNTAINS
BAIRD MOUNTAINS
Noatak River
Kobuk River
Kotzebue Sound
Waring Mts.
John R.
Haul Road
Chandalar R.
Sheenjek River
YUKON FLATS N.W.R.
RICHARDSON MOUNTAINS
Peel R.

FIGURE

Figure III-2.--Physiographic divisions of northeastern Alaska. Slightly modified, after Wahrhaftig, 1965.

study of flood characteristics of streams in the ANWR found that maximum evident flood-peak discharge rates averaged about 40 cubic feet per second per square mile.

The size and relative streamflow of the principal rivers within the ANWR study area are summarized in table III-1, which lists the major rivers across the eastern Arctic Slope.

The primary cause of floods in the ANWR is rapid spring snowmelt. The height of the floodflow is significantly increased by the presence of ice jams during spring breakup. In spring (May and June), melt water begins to accumulate and flow over the surface of the inland ice and on the deltas. As the river ice fractures and breakup begins, melt water combines with the increasing downstream flow of freshwater to rapidly flush the seawater from the lower rivers and deltas. Wide variations exist in the magnitude of spring flooding, as well as the likelihood of summer flooding, depending on whether river systems head in snowfields or flow through large lakes, as in the case of the Sadlerochit. As breakup continues, extensive flooding permits rapid movement of ice toward the sea, where floodwater and block ice move onto and beneath the sea ice. Sediment loads are at their peak during flooding, and considerable deposition (several centimeters) of fine material may occcur on the sea ice surface. The freshwater and sediments are soon drained through cracks and holes in the sea ice which develop with changes in the thermal regime (H. J. Walker, 1974). Following breakup, flooding drops off rapidly. Due to the low summer rainfall, there is little chance of summer flooding, but fall storms in the mountains can cause high water conditions.

Lakes are not a conspicuous hydrologic feature in the ANWR study area. Shallow thaw-lakes do occur, however, along the coast and adjacent to the main river deltas. They are most common on the broad, nearly level deltas of the Canning and Hulahula Rivers. Nearly all of the lakes are less than 1 square mile in area. Most are less than 6½ feet deep and freeze to the bottom in winter. There are no glacial lakes within the study area.

Widespread permafrost limits the occurrence of ground water in the ANWR. There are no water wells in the ANWR, but there are several springs of considerable significance. Sadlerochit Spring discharges from bedrock on a hillslope at the eastern end of the Sadlerochit Mountains. This spring maintains a nearly steady discharge of 37 cubic feet per second at a temperature of about 55°F (13°C). This amounts to about 24 million gallons of water a day. Shublik Spring, located outside the study area, influences the water supply of the Canning River. Large springs also occur on the Hulahula, Okerokovik, Aichilik, and Kongakut Rivers, and small springs occur on several other rivers.

Water availability on ANWR varies seasonally. Springs are the most obvious source of winter water. Water stored as snow or ice through the winter and early spring is frequently used as a source of water supply. A lake is used for water supply at Barter Island, but its quality becomes poor in late winter because of freeze concentration of dissolved solids. At that time, lake ice is usually melted for water use.

Turbidity resulting from suspended sediments is the most visible impairment of water quality. Suspended-sediment concentrations are highest in the major streams and rivers during spring breakup and during periods of high summer flow.

Table III-1.--Size and relative streamflow of the principal rivers, eastern Arctic Slope

(Table modified from Childers and others, 1977)

	BANKFULL CHANNEL						MAXIMUM EVIDENT FLOOD		
Stream site	Streambed material	Slope (ft/ft)	Width (ft)	Mean depth (ft)	Max depth (ft)	Discharge (ft^3/s)	Width (ft)	Discharge (ft^3/s)	Unit runoff $(ft^3/s)/mi^2$
Colville River 70°09'56" 150°05'50"	fine gravel	0.00056	2,240	25.2	57	683,000	2,230	600,000	29.0
Shaviovik River 70°05'07" 147°16'30"	coarse cobble	0.0012	1,510	4.2	7	22,000	1,510	22,000	13.0
Canning River 69°50'38" 146°27'10"	large cobble	0.0012	960	6.9	14	31,000	1,150	53,000	28.3
Katakturuk River 69°52'25" 145°27'10"	coarse gravel	0.0064	680	3.7	7	17,000	670	10,000	43.9
Marsh Creek 69°47'32" 144°49'00"	coarse gravel	0.0148	560	3.4	6	14,000	280	500	1.9
Sadlerochit River 69°39'13" 144°12'10"	boulders	0.0062	280	4.5	7	11,000	280	11,000	20.8
Hulahula River 69°41'47" 144°12'10"	coarse gravel	0.0050	250	7.2	9	23,000	240	10,000	14.7
Jago River 69°37'02" 143°41'06"	boulders	0.0132	180	5.9	7	14,000	180	14,000	43.6
Okerokovik River 69°42'07" 143°14'23"	coarse gravel	0.0033	590	3.4	7	10,000	360	2,300	13.6
Aichilik River 69°35'23" 142°58'03"	coarse gravel	0.0054	820	5.5	8	33,000	817	27,000	48.0
Egaksrak River 69°32'05" 142°41'05"	large cobble	0.0093	560	2.4	6	9,000	560	9,000	41.9
Ekaluakat River 69°34'35" 142°18'38"	medium gravel	0.0109	730	3.1	6	23,000	860	27,000	185.0
Kongakut River 69°30'54" 142°42'34"	coarse gravel	0.0058	2,770	4.6	9	98,000	2,770	98,000	79.0
Turner River 69°35'56" 141°24'10"	medium gravel	0.0038	160	1.7	6	1,300	170	1,500	29.4

During low-flow periods, all the streams are essentially clear. Some of the shallow lakes also become turbid during the summer, when wind and wave action disturb bottom sediments. Aside from periods of turbidity, the water in most rivers and lakes is virtually colorless. Tea-colored waters, resulting from high concentration of dissolved organic materials, occur in some of the small tundra streams and lakes. Some rivers are turbid throughout the summer as a result of the their glacial origin (Aichilik, Jago, Okpilak, Hulahula, Canning).

Water quality in lakes and streams is reduced in winter because of freeze concentration. The amount of concentration depends on the ratio of water to ice in a water body when maximum ice thickness is reached. Water in shallow lakes and river pools that freeze nearly to the bottom can become unpotable in late winter.

Dissolved oxygen in water is at or near saturation in the lakes and streams of the ANWR during summer, but levels of dissolved oxygen can be severely depressed under ice cover in winter, owing to the lack of reaeration and extended darkness that limits photosynthetic activity. Low dissolved-oxygen contents are most prevalent in water bodies that freeze nearly to the bottom.

The water quality of springs in the ANWR is very good. The water is colorless and odorless, has little taste, is fairly low in total dissolved solids, and is fairly constant in temperature, chemistry, and discharge throughout the year.

Climate and Meteorology

The climate of the ANWR study area is in the Arctic zone. Summers are short, cool, and generally cloudy. Temperatures of the warmest month (July) average about 5°C, with maximum temperatures rarely exceeding 30°C. Winters are very cold, with temperatures of the coldest month (February) averaging about -20°C. Extreme lows frequently drop below -40°C. High surface winds common throughout the year result in wind chill factors well below actual temperatures.

The Arctic coast experiences frequent cloudiness and fog, and high winds. At Barter Island, total cloud cover occurs 54 percent of the year, and fog may be expected at least 115 days. Inland, clear skies are more common and winds are variable and temperature ranges and extremes tend to be greater. This contrast is intensified during the late summer and fall months when there is open water along the coast, although even in winter when the Arctic Ocean is frozen over, air temperatures reflect some marine influence.

Based on precipitation alone, the Arctic Coastal Plain can be considered arid, with average annual rainfall less than 25 cm (10 inches), including the water equivalent of 30-120 cm of snowfall. Summer rainfall accounts for most of the total precipitation. Snowfall may occur in any month, with heaviest snowfall usually occurring in October. Snow deeper than 1 foot (30 cm) persists for many days each winter throughout the ANWR.

Almost continuous winds move and redistribute snow, causing bare or nearly bare ridgetops and drifted valleys. At present, little information is readily available to determine the distribution of snowfall and wind effects upon the removal/accumulation of snow cover in the study area. An inference on the nature of the dynamics of the snow cover for the study area can be drawn from the report

by Swan and others (1978). The report provides an example of the snow depth from the coast to mountain gradient in the NPR-A area. Benson and others (1975) and Everett and Parkinson (1977) reported an average April wind-packed snow depth of 30 to 40 cm for the Prudhoe Bay area. The snow pack ranges anywhere from a few centimeters to as much as 20 cm of recrystallized, low density "depth hoar" with an upper layer of higher density wind-packed snow.

In the open landscape of the tundra, the ever-blowing winds constantly shift dry snow from place to place. In the cold air, and especially in the areas where large amounts of moisture are increased through combustion of hydrocarbons, the moisture in the air precipitates out as thin needle-shaped crystals. Even with weak winds, needles colliding with one another or with the ground result in extremely fine snow dust which fills the air and provides the sinuous streams of snow dust. As wind strength increases, a fine snowy fog is created giving rise to the commonly encountered limited visibility and "whiteouts."

The typical snow cover cross section on the tundra commonly shows a succession of hard wind-packed layers overlying a coarse granular layer with little cohesion ("depth hoar") (Keller, 1972). The depth hoar results from the combination of initially loose freshly fallen snow becoming overlaid by a hard wind-packed layer, and by subsequent upward movement of water vapor along the temperature gradient, from the warmer ground surface to the colder snow surface. One or more ice layers can form in the snow pack as the result of the thaw, downward percolation of meltwater, and subsequent freezing. Ice layers tend to make the snow pack dense and cohesive.

The prevailing easterly winds at Barter Island average about 13 knots windspeed. Westerly winds can be much more intense than the prevailing easterlies and have been measured as high as 80 knots at Barter Island.

Wind effects are dramatically portrayed along the shoreline and shoreline bluffs. Seaward-facing bluffs along the shore show the eroding effects of winds through gullying and stripping of tundra vegetation. Wind erosion is dramatically displayed by the extensive east-west erosion scars of the active sand dunes of the Canning, Hulahula, Okpilak, and Jago River Deltas. Coastal bluff crests and their soils undergo natural profile disruption by mixing from frost action and by wind abrasion. Because they are exposed, bluff crests and their soils are commonly snow-free during winter. The natural instability of the bluff faces make them very susceptible to outside disturbances, especially those that induce channeling or ponding of melt waters.

Few, if any, air quality measurements have been made in the ANWR. However, since few local pollution sources exist, it is reasonable to assume that air quality is good. Recent evidence indicates that some pollution does occur from distant sources, most likely located in Eurasia. The amount of particulate matter in the air, however, may be locally high, especially during dry summer periods, because of wind-borne dust from beaches, and bars, and other bare areas, such as riverbanks and flood plains. Smoke from tundra fires in the ANWR may, on rare occasion, cause some localized air pollution. Winds occasionally transport smoke to the area from more distant fires south of the Brooks Range, mainly during the summer months.

Geologic Processes

The following description of certain geologic processes emphasizes those natural phenomena that directly pertain to evaluating environmental impacts that could result from seismic oil and gas exploration. During the 8- to 9-month winter season most of the geologic processes described here are inactive because the ground is frozen, surface streamflow is practically nonexistent, and the Beaufort Sea is covered with ice. However, disturbance of the vegetation mat during the winter season can result in serious environmental problems that will manifest themselves during subsequent summer months.

With regard to seismic exploration activities, permafrost degradation is, by far, the most critical geologic hazard. In addition, it exacerbates most slope stability and erosion problems.

In the study area, the character of the geologic materials, along with the elevation, interrelated slope, and drainage conditions, determines the character of the permafrost and, therefore, the potential severity of permafrost degradation or thawing, the potential for landslides and mass wasting, and the susceptibility of materials to erosion.

Permafrost Degradation

Permafrost is defined as soil, rock, or any other earth material whose temperature remains below $0^{o}C$ ($32^{o}F$) continuously for 2 or more years (Muller, 1943, p. 3). Most of the permafrost in Alaska has been in this frozen condition for many thousands of years; some is slowly degrading (growing thinner), but some is aggrading (growing thicker) today. The factors that control the distribution of permafrost also control its temperature, which varies markedly with depth, latitude, and geologic and topographic setting.

Even in the coldest parts of Alaska, a thin layer of ground, the "active layer," thaws every summer and separates the permafrost from the ground surface. The thickness of the active layer depends upon moisture contact and the capacity of the surface material to protect the underlying permafrost from summer heat. It can vary locally from one-half foot to 5 feet or more and can change dramatically when the surface is disturbed.

During winter, thermal contraction of the ground surface in northern Alaska causes it to crack in a pattern resembling mud cracks, only much larger (Lachenbruch, 1962). Summer melt water pours into these cracks in the permafrost and freezes, forming a vertical network of intersecting ice veins. As centuries pass, repeated cracking at these sites of weakness causes these veins to grow into a network of massive wedges of ice, often tens of feet deep, several feet wide at the top, and separated from one another by 100 feet or more. Ice wedges are sometimes indicated by polygonal ground surface markings, but more often they are not. Other forms of ice, including lenses of all sizes and interstitial forms, are also common in permafrost.

Disturbance of the ground surface can cause thawing of permafrost and slope failures. Such effects can be caused by damage to the organic surface layer, by disrupted surface drainage, or by gravel pads. Such modifications can have a critical effect on the ground surface, but it may take several years before the effects are fully manifest.

The primary problems resulting from thawing of permafrost relate to potential loss of strength and volume (Ferrians, Kachadoorian, and Greene, 1969). In ice-rich material, this can cause severe differential settlement or liquefaction of the soils. Such effects are often irreversible and under adverse conditions may be self-perpetuating and difficult to predict.

The ANWR study area is within the continuous permafrost zone. In northern Alaska, where the climate is extremely cold, permafrost forms a virtually continuous layer to depths of several hundred feet beneath the surface and locally to as much as 2,000 feet beneath the surface.

The unconsolidated materials in the study area that are not frozen year-round at shallow depths are the unvegetated active flood-plain deposits (sandy gravel and sand) which are present in the larger drainageways. The depth to which these materials are thawed depends upon the size of the drainageway and the amount of water flowing in it. Also, certain spits and bars in the coastal area are free of permafrost near the surface. The large amount of heat in the water keeps these materials thawed during the summer months. The extensive vegetated terraces that border the active flood plains also are underlain by sand and gravel deposits, but these deposits generally are overlain by several feet of sandy silt or fine silty sand and an organic mat of peat. These deposits commonly contain ice and are frozen year-round, except for a thin active layer.

Most of the low-lying areas, which comprise the bulk of the study area, are underlain by extremely ice-rich fine-grained deposits. Ice-wedge polygons are the dominant form of ground ice in this area (Leffingwell, 1915); however, other forms of ground ice are also common. Well-indurated bedrock, which is limited in the area, has few voids and, consequently, does not contain large quantities of ground ice.

Landslides and Mass Movement

Landslides and mass movements (the downslope movement of soil and/or rock material en masse under the direct influence of gravity) can occur on very gentle slopes but are more common on steep slopes. Landslide movement is very rapid and occurs as falls, flows, slumps, or slides. Other forms of mass movement are slow. For example, solifluction takes place discontinuously in response to near-surface processes. Solifluction is especially prevalent in the study area because the permafrost forms an impervious layer under the active layer. During the summer, the materials in the active layer thaw and become saturated because the moisture is trapped above the permafrost table. In areas of sloping terrain, these saturated materials tend to move downslope, resulting in solifluction.

The low-lying portions of the study area are expecially sensitive to surface disturbance and, when disturbed, will thaw and move downslope as landslides. This process is especially active along sea bluffs, terrace escarpments marginal to drainageways, and margins of lakes.

Poorly consolidated Tertiary shale, siltstone, and sandstone bedrock underlie, at depth, a large part of the study area, and crop out along the valleys of the Canning, Tamayariak, and Niguanak Rivers and in the area of Marsh and Carter Creeks. Locally, these deposits are susceptible to mass movements, and along the Katakturuk River and in the area of Marsh and Carter Creeks, numerous landslides have occurred.

Erosion

Erosion includes the mechanical and chemical breakdown of soil and rock and the transport of this material by running water, waves, currents, ice, or wind. Most erosion in the study area is caused by running water and takes place along all the drainageways, but it is greatest along the major rivers. Coastline erosion is also important locally because wave action, in conjunction with thawing permafrost, can cause extremely rapid retreat of coastal bluffs during major storms, especially when tides are high. Leffingwell (1919) reported shoreline recession rates of more than 30 feet per year, and Wiseman and others (1973) measured 164 feet of bluff erosion in the eastern end of Pingok Island during a 3-week period of 1972. Shorelines of the larger lakes are eroded primarily by thawing of permafrost.

Wind erosion is relatively minor except in the delta areas of the Canning, Hulahula, Okpilak, and Jago Rivers, where sand dunes are active. Easterly winds pick up material from the extensive unvegetated sand bars in the braided channels of the deltas and form cliffhead dunes along the western banks of the rivers.

BIOLOGICAL ENVIRONMENT

Terrestrial and Freshwater Environments

Vegetation and Terrain Types

The vegetation of the entire study areas lies within the tundra formation (Aleksandrova, 1970). In the tundra region, mesic (moderately wet) habitats are mostly continuously vegetated with low-growing plants, such as sedges, grasses, mosses, lichens, small herbs, and dwarf shrubs. Taller shrubs are restricted to drainages protected from winter winds and snow abrasion and to slopes with southern exposures.

Keys to the soils, landforms, vegetation, and landcover categories (table III-2) were developed from color infrared photographs (1:60,000) and from a ground-truth reconnaissance survey in 1981. A preliminary Landsat landcover map of the study area (pl. 1) and a derived simplification of this map (pl. 2) were produced in October 1981 from these field data. Planimetry data are given for the Landsat landcover categories within each terrain type and for the entire study area in appendix B, tables B-2 and B-3. The classification contains 12 landcover units:

(I)	Water
(II)	Pond Sedge Tundra Complex; Aquatic Tundra or Shallow Water
(III)	Wet Sedge Tundra
(IV)	Moist/Wet Sedge Tundra Complex; or Dry Prostrate Shrub, Forb Tundra
(V)	Moist Sedge, Prostrate Shrub Tundra; or Moist Sedge/Barren Tundra Complex
(VI)	Moist Tussock Sedge, Dwarf Shrub Tundra
(VII)	Moist Dwarf Shrub, Tussock Sedge Tundra; or Moist Sedge Tussock, Dwarf Shrub/Wet Dwarf Shrub Complex
(VIII)	Shrub Tundra
(IX)	Partially Vegetated Areas

(X) Barren Gravel or Rock
(XI) Wet Gravels, or Mud
(XII) Ice

Six regionally significant terrain types occur within the study area (fig. III-3; table III-3). Five of these are discussed in the following sections. The sixth is the 339 km^2 of ocean water that occurs within the study boundary. (See appendix B for additional photographic displays of terrain, soils, and vegetation types.)

Flat Thaw-Lake Plains

Thaw-lakes, drained lake basins, and expanses of low-centered ice-wedge polygons are found in only a few small areas of the ANWR coastal plain, primarily near the flat braided deltas of rivers (fig. III-4) and cover only 3 percent of the study area. The best developed example of thaw-lake topography occurs in the delta-confluence of the Canning and Tamayariak Rivers, an area of less than 100 square kilometers, and for some 12-15 km eastward in a narrow coastal belt; and in a narrow zone between the delta of the Hulahula River and a point some few kilometers east of the Jago River.

Except for the vegetation-covered basins of relatively recently drained lakes, some form of microrelief is nearly always present, consisting mostly of low-centered polygons, strangmoor, and featureless areas associated with pond complexes. (Note cover background photograph.)

In the thaw-lake plains, microtopography (on a scale of less than 1 m of elevation difference) plays the major influence on the distribution of plant communities. The small elevation differences create distinct patterns of plant communities and soils associations (Wiggins, 1951; Cantlon, 1961; Britton, 1957; D. A. Walker, 1981). The dominant Landsat land cover categories in the thaw-lake plains are Wet Sedge Tundra (app. B, fig. B-17), Water, Moist/Wet Sedge Tundra Complex (app. B, figs. B-18 and B-19), Aquatic Tundra (app. B, fig. B-20), and Pond Complex (background photograph on cover). The area is underlain by ice-rich permafrost at depths of about 40 cm. Except for polygon rims, the perched water table is very close to the surface or slightly above it for most or all of the thaw period.

Thaw-lake plains and coastal marshes are particularly valuable habitat for waterfowl. Spindler and Knudtson (1978) reported that flooded tundra areas are the most valuable to nesting birds on the Arctic coastal plain.

Hilly Coastal Plains

The coastal plain also contains extensive areas of gently rolling topography (fig. III-5). This type of terrain, common within the coastal plain of ANWR, covers over 22 percent of the study area. East of the Hulahula River parallel to the coast, there are numerous lightly elevated ridges and expressions, mostly with less than 30 m of relief contrast. Flat, gently sloping (5 percent or less) interfluve areas contain complexes of wet and moist tussock tundra associated with poorly developed flat-centered ice-wedge polygons. Vegetation on the ridges is mainly Moist Sedge, Prostrate Shrub Tundra and Moist Sedge/Barren Tundra Complex. (Next descriptive text begins on page IV-29.)

Table III-2.--Preliminary descriptions of vegetation and soils within the Landsat landcover categories for the Arctic National Wildlife Refuge

(In most cases colors on the Landsat image include several tundra types. The dominant types are described here, but not in order of importance)

	Color	Unit(s)	Description of vegetation and landcover units	Description of soils and landforms
I.	Dark blue	Water	Larger water bodies generally greater than 1 acre in size, ocean, lakes, and rivers.	No soil identified.
II.	Aqua	Pond Complex or Aquatic Tundra	IIa. Pond Complex.--Very wet tundra areas that have numerous small bodies of water such as in drained lake basins with small ponds, polygons, and strangmoor. Relatively well drained tundra of varying character may cover up to 50 percent of the unit. Low-centered polygon complexes with standing water in their centers are usually included in this unit.	IIa. Pond Complex.--Principal landforms of the pond complex are numerous shallow ponds less than 1 hectare, low-centered polygons, often with standing water in their centers and string bogs (strangmoor). The very wet elements of the unit have, in order of abundance, Histic Pergelic Cryaquepts usually with 20 cm or more of fibrous organic material over gleyed (reduced) mineral soil. Pergelic Cryaquepts with less than 20 cm of fibrous organic over gleyed mineral material or Cryofibrists with greater than 40 cm of fibrous organic over gleyed mineral soil. Positive microrelief elements, especially well-developed (greater than 20 cm) rims of the low-centered polygons have Pergelic Cryaquolls or occasionally Pergelic Cryaquepts with 5 to 10 cm of highly decomposed organic matter overlying gleyed mineral soil. The Pergelic Cryaquolls and, in rare circumstances, Pergelic Cryosaprists are the organically oxidized extensions of the Cryofibrists in polygon centers.
			IIb. Aquatic Tundra.--Emergent communities that cover areas greater than 1 acre. The primary taxon in deeper water, up to 1 m deep, is Arctophila fulva (Pendent Grass). In shallow water, less than 30 cm deep, the main taxa are Carex aquatilis (Aquatic Sedge), Eriophorum scheuchzeri (Arctic Cottongrass), and E. angustifolium (Common Cottongrass).	IIb. Aquatic Tundra.--Normally soils have not been described in areas where Arctophila fulva is mapped. The substrate in such environments consists commonly of a suspension of detrital organic materials often with a significant component of mineral materials held in a matrix of plant roots. Underlying mineral soils may be uniformly gleyed or on occasion show mottles, the result of oxidation around aerenchymous roots. Such soils are placed provisionally with the Pergelic Cryaquepts. Similar soils with increasing amounts of fibrous biomass occur within the shallower (less than 30 cm) water depths.

III.	Dark green	Wet Sedge Tundra	IIIa. Wet Sedge Tundra (Non-complex Type).--Relatively wet tundra with shallow or no standing water and only a few well-drained microsites associated with polygon rims, strangmoor, hummocks, etc. Much of this tundra is flooded in early summer but generally drains of standing water by mid-summer and remains saturated throughout the summer. Relatively large areas of non-complex wet tundra occur in the deltas of the large rivers, particularly the Canning River, and in drained lake basins and along some river channels. The primary taxa are numerous sedges, including Carex aquatilis (Aquatic Sedge), Eriophorum angustifolium (Common Cottongrass), E. russeolum (Russet Cottongrass), C. rotundata (Round-fruited Sedge), C. saxatilis (Rocky Sedge); a few herbs, including Pedicularis sudetica ssp. albolabiata (Sudetan Lousewort), Saxifraga hirculus (Bog Saxifrage), Melandrium apetalum (Nodding Lychnis), Caltha palustris (Marsh Marigold), and Potentilla palustris (Marsh Fivefinger). Mosses are mainly Drepanocladus spp., Scorpidium scorpioides, Campylium stellatum, Calliergon spp., and Sphagnum spp.	IIIa. Wet Sedge Tundra (Non-complex Type).--These areas have seasonal standing water (after snowmelt), but by mid-summer the thickening active layer together with evapotranspiration removes the standing water leaving a saturated soil; free water is encountered within a very few centimeters of the surface. Patterned ground features are poorly developed and consist of large disjunct polygons, hummocks, and strangmoor; the strangs are often coextensive with the low rims of polygons. All in all, there is not much positive microrelief. The soils, like the surface, are wet, predominantly Pergelic Cryaquepts or Histic Pergelic Cryaquepts, both of which have fibrous organic horizons. In certain cases where organic and neutral- to alkaline-mineral substrate is present, Histic Pergelic Cryaquolls occur.
			IIIb. Wet Sedge Tundra (Very Wet Complexes).--Complexes of wet tundra with up to 50 percent water or emergent vegetation. Low-centered polygon complexes, areas with extensive thermokarst pits, or complex thermokarst areas in the foothills are common areas with this vegetation subunit. Non-aquatic portions of the complex may be tundra of varying character including Moist Non-tussock Tundra (Va), Moist Tussock Sedge, Dwarf Shrub Tundra (VI), Dry Sedge, Crustose Lichen Tundra (Va), and Wet Saline Tundra (IIId).	IIIb. Wet Sedge Tundra (Very Wet Complexes).--In contrast to IIIa, these are areas with more strongly expressed surface patterns and microrelief and with significant amounts of standing water in the form of thermokarst pools or in the centers of low-centered polygons. Such areas are typical of broad crests in the foothills regions and portions of the rolling coastal plain. Moist tussock and tussock frost-scar slopes in this subregion have Pergelic Cryaquolls and/or Ruptic-Entic Cryaquolls. Pergelic Cryaquolls commonly form associations with Pergelic and Histic Pergelic Cryaquepts where low-centered polygons are well expressed. Complexes of Pergelic Cryaquolls and Pergelic and Histic Pergelic Cryaquepts characterize the unit generally.

Table III-2.--Preliminary descriptions of vegetation and soils within the Landsat landcover categories for the Arctic National Wildlife Refuge--Con.

	Color	Unit(s)	Description of vegetation and landcover units	Description of soils and landforms
III.	Dark green	Wet Sedge Tundra	IIIc. Wet Sedge Tundra (Moist Complexes).--Complexes of wet tundra with up to 40 percent moist tundra of varying character. Low-centered polygon complexes with well-developed polygon rims, and string-bogs with closely spaced strangs are common areas with this vegetation subunit.	IIIc. Wet Sedge Tundra (Moist Complexes).--This subunit differs from the others principally in terms of being better drained. There are more extensive areas of well-developed low-centered polygons and areas of string bogs in which the strings are more closely spaced, reflecting a more clearly defined hydraulic gradient. Pergelic and Histic Pergelic Cryaquepts are common to the rest of the subunit.
			IIId. Wet Sedge Tundra (Saline Facies).--Areas near the coast that are periodically inundated with salt water. The primary taxa are Carex subspathacea, (Hoppner Sedge), Puccinellia phryganodes (Creeping Alkali-grass), C. ursina (Bear Sedge), Stellaria humifusa (Low Chickweed), and Cochlearia officinalis (Common Scurvy Grass). Some saline areas have numerous ponds and are likely to be classed as Pond Complex (II).	IIId. Wet Sedge (Saline Facies).--These near-coast areas may display any of the landform subunits of categories II or III except IIIb. The soils in recently flooded areas are morphologically little different from those of the unflooded parts. Chemically, however, they may have conductivities that range from 12,000 to greater than 18,000 umhos/cm and should probably be considered as Halic Pergelic Cryaquepts (proposed by S. Rieger, in press) and, in some cases, Halic Histic Pergelic Cryaquepts. Where saline conditions have prevailed for a protracted period of time and salt-tolerant plants, such as Puccenellia phryganodes and Carex subspathacea, are established on the dead Carex aquatilis there is a pronounced change in the texture of the accumulating organic matter
IV.	Light green	Moist/Wet Sedge Tundra Complex or Dry Prostrate Shrub, Forb Tundra (problem category)	IVa. Moist/Wet Sedge Tundra Complex.--Areas of moist sedge tundra mixed with up to 40 percent wet sedge tundra. Flat areas with low- or flat-centered polygon complexes (common in drained lake basins) or strangmoor (more common in river delta systems and on gentle slopes) usually have a large percentage cover of wet tundra in the polygon troughs, basins, thermokarst pits and inter-strang areas. The spectral signature of these areas are likely to vary depending on the season and the summer rainfall. Moist areas may or may not have cottongrass tussocks, depending on proximity to the coast. Common taxa in moist tundra areas include the sedges Eriophorum triste (Common Cottongrass), E. vaginatum (Sheathed Cottongrass),	IVa. Moist/Wet Sedge Tundra Complex.--Occurs on flat upland areas or in old drained lake basins where flat-centered polygons form complexes with thermokarst pits or with strangmoor. Wet areas may comprise up to 40 percent of any given area. The moist/wet sedge tundra is also common to gentle slopes with flat-centered polygons. The IVa subunit is most extensive east of the Hulahula River. Soils of the moist areas (polygon centers especially) are Pergelic Cryaquolls. Those of the wet sites are Histic Pergelic Cryaquolls or Histic Pergelic Cryaquepts. In areas where frost scars are common to the moist sites, the soil complex is best described as one of Ruptic-Entic Pergelic Cryaquolls.

IV.	Light green	Moist/Wet Sedge Tundra Complex or Dry Prostrate Shrub, Forb Tundra (problem category)	Carex bigelowii (Bigelow's Sedge), C. membranacea (Fragile Sedge); the prostrate shrubs Dryas integrifolia (Arctic Avens), Salix reticulata (Net-veined willow), S. arctica (Arctic Willow), S. pulchra (Diamond-leafed Willow), S. lanata (Woolly Willow); and the forbs Pedicularis lanata (Woolly Lousewort), Polygonum bistorta (Bistort), Stellaria laeta (Long-stalked Stitchwort), and Senecio atropurpureus ssp. frigidus (Arctic Senecio). Common bryophytes include Tomenthypnum nitens, Hylocomium splendens, Ptilidium ciliare, Orthothecium chryseum, and Ditrichum flexicaule. Common lichens are Thamnolia subuliformis, Cetraria ssp., Dactylina arctica, Cladonia spp., and Cladina spp.	

IVb. Dry Prostrate Shrub, Forb Tundra (Dryas River Terraces).--River terraces with a dense prostrate mat of Dryas integrifolia and numerous small forbs and prostrate shrubs. This unit is quite dark on aerial photography and Landsat data and has a spectral signature similar to either Wet Sedge Tundra (III) or Moist/Wet Sedge Tundra Complex (IVa), although this unit is physiognomically very different from either of these other units. This is a common unit along rivers, particularly along the Canning River, and used heavily by ground squirrels, lemmings, and bears. It may be possible to distinguish these terraces in some other phenological stage on Landsat scenes taken later in the summer. The primary taxa are the prostrate shrubs Dryas integrifolia (Arctic Avens), Salix reticulata (Net-veined Willow), S. rotundifolia (Round-leafed Willow), and S. ovalifolia (Oval-leafed Willow); the herbs Astragalua alpinus (Alpine Milk-vetch), Oxytropis nigrescens (Blackish Oxytrope), Equisetum arvense (Common Horsetail), Artemisia

IVb. Dry Prostrate Shrub, Forb Tundra (Dryas River Terraces).--These terraces are generally components of the riverine complex. Except under unusual circumstances they are not flooded, being a meter or more above the active terraces or river island complex. Surfaces of these terraces still display the river island and channel features. The river island component commonly displays polygonal cracks and has soils resembling Cryofluvents with 15 to 50 cm of interlayered silts, sands, and organic materials overlying riverwash sands and gravels. Permafrost is greater than 1 m and no water table occurs. Former channels are wet to moist and have Pergelic Cryaquept soils.

Table III-2.--Preliminary descriptions of vegetation and soils within the Landsat landcover categories for the Arctic National Wildlife Refuge--Con.

	Color	Unit(s)	Description of vegetation and landcover units	Description of soils and landforms
IV.	Light green	Moist/Wet Sedge Tundra Complex or Dry Prostrate Shrub, Forb Tundra (problem category)	arctica (Arctic Wormwood), Silene acaulis (Moss Campion), Chrysanthemum integrifolium (Entire-leafed Chrysanthemum), Saxifraga oppositifolia (Purple Mountain Saxifrage), Carex membranacea (Fragile Sedge), and Eriophorum triste (Common Cottongrass); and the mosses Distichium capillaceum and Ditrichum flexicaule.	
V.	Sand	Moist Sedge, Prostrate Shrub Tundra or Moist Sedge/ Barren Tundra Complex (problem category)	Va. Moist Sedge, Prostrate Shrub Tundra.--Moderately well drained areas, located primarily along the northern part of the foothills and in drainages. Principal taxa are similar to those described for Moist/Wet Sedge Tundra Complex (IVa). These areas may have up to 20 percent cover of cottongrass tussocks. Wetter facies near streams are likely to have no tussocks and to have high percentages of prostrate shrubs, including Salix arctica (Arctic Willow) and S. pulchra (Diamond-leafed Willow), and herbs such as Petasites frigidus (Lapland Butterbur), Saxifraga punctata (Cordate-leafed Saxifrage), Carex aquatilis (Water Sedge), Saxifraga hirculus (Bog Saxifrage), and Valariana capitata (Capitate Valerian). Near the coast, on slightly elevated microsites, moist tundra areas are likely to contain large components of a prostrate shrub, crustose lichen type. This type is a rather sparse community including Dryas integrifolia (Arctic Avens), Salix pulchra (Diamond-leafed Saxifrage), Carex bigelowii (Bigelow's Sedge), S. phlebophylla (Veiny-leafed Willow), Luzula arctica (Arctic Wood-rush); with considerable groundcover of small hummocks with the moss Dicranum elongatum covered by white crustose lichens (mainly Ochrolechia frigida and Lecanora epibryon). Vb. Moist Sedge/Barren Tundra Complex (Frost-scar Tundra).--Well-drained areas with as much as 90 percent of the surface covered by frost-boils or frost-rings. Vegetation on the frost scars is generally sparse with such taxa as Juncus biglumis	V. Moist Sedge, Prostrate Shrub Tundra or Moist Sedge/Barren Tundra Complex.--This cover category is mostly in the northern or rolling foothills of the wildlife refuge and is commonly difficult to separate from landcover unit IVa in that it occupies broad sloping interfluves with flat-centered polygons. The soils are Pergelic Cryaquolls with a small percentage of Pergelic Cryaquepts. Portions of the slopes have a very high percentage of frost scars--in some cases 75 percent or more. These areas are especially common on crests with bedrock at or close to the surface and areas low on the slopes near drainages. Soils of the frost scars are Pergelic Cryaquepts; more stable areas between the frost scars (10 to 50 percent of the surface) are Pergelic Cryaquolls. Active layer thickness ranges from near a meter in the scars to between 40 and 60 cm beneath the Pergelic Cryaquolls. Portions of the long, low slopes are characterized by tussock-water track tundra (landcover unit VIIc).

V.	Sand	Moist Sedge, Prostrate Shrub Tundra or Moist Sedge/ Barren Tundra Complex (problem category)	(Two-flowered Rush), Arctagrostis latifolia (Wide-leafed Arctagrostis), Petasites frigidus (Lapland Butterbur), Dryas integrifolia (Arctic Avens), Chrysanthemum integrifolium (Entire-leafed Chrysanthemum) and Saxifraga opositifolia (Purple Mountain Saxifrage, and the mosses Rhacomitrium lanuginosum, Bryum spp., Distichium capillaceum, Drepanocladus uncinatus, etc. Inter-frost-scar areas near the coast are usually Moist Sedge Tundra (Va) dominated by Carex bigelowii (Bigelow's Sedge), Dryas integrifolia (Arctic Avens), Arctagrostis latifolia (Wide-leafed Arctagrostis), Equisetum arvense (Common Horsetail), and the moss Tomenthypnum nitens. In the foothills frost-scar tundra occurs mainly on slopes and ridge tops and is likely to have scattered dwarf shrubs (10 to 40 cm tall) of Salix lanata (Woolly Willow) or S. glauca (Northern Willow). This unit is extensive but is difficult to separate on the Landsat data. On the Flaxman scene, it is most often classified as Unit V (sand), whereas on the Canadian scene, it often appears as Unit IV (light green).	
VI.	Light brown	Moist Tussock Sedge, Dwarf Shrub Tundra	VIa. Moist Tussock Sedge, Dwarf Shrub Tundra (Upland Tussock Tundra, Acidic Facies).-- Relatively well drained upland tussock tundra sites primarily in the foothills with high percentage cover of cottongrass tussocks and dwarf or prostrate shrubs. Tussocks are usually dominant with about 20 to 70 percent cover. On acidic soils the dwarf shrubs include Salix pulchra (Diamond-leafed Willow), Betula nana (Dwarf Birch), Ledum decumbens (Narrow-leafed Labrador Tea), Vaccinium uliginosum (Bog Blueberry), V. vitis-idaea (Mountain Cranberry, Empetrum nigrum (Crowberry), Arctostaphylos rubra (Bearberry), and Cassiope tetragona (Four-angled Mountain Heather); and the bryophytes are mainly Hylocomium splendens, Sphagnum spp., Aulacomnium palustre, and Ptilidium ciliare. Lichens are dominated by Cladonias and Cladinas.	VI. Moist Tussock Sedge, Dwarf Shrub Tundra.-- Two facies, acid and alkaline, are recognized in this foothills unit. Landforms are principally long slopes dominated by cottongrass tussocks that obscure flat-centered polygons. The acidic facies of the unit occur in association with sand and gravel conglomerate units of the underlying Cretaceous and/or Tertiary bedrock and are particularly common in the area west of the Katakturuk River. The soils are Pergelic Cryaquepts and form a complex with numerous frost scars (Ruptic-Entic Pergelic Cryaquepts). Histic Pergelic Cryaquepts are common where water track units occur. Alkaline facies of this cover category are most common east of the Katakturuk River and the soil complex is Ruptic-Entic Pergelic Cryaquolls. Water tables are generally absent in the moist portions of both

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	Color	Unit(s)	Description of vegetation and landcover units	Description of soils and landforms
VI.	Light brown	Moist Tussock Sedge, Dwarf Shrub Tundra	VIb. Moist Tussock Sedge, Dwarf Shrub Tundra (Alkaline Facies).--Tussock tundra on more neutral or basic soils. Important taxa include Dryas integrifolia (Arctic Avens), Carex bigelowii (Bigelow's Sedge), Salix arctica (Arctic Willow), S. reticulata (Net-leafed Willow), S. lanata (Woolly Willow); the chief moss is Tomenthypnum nitens; and lichens are mainly Cetrarias. The alkaline soils are most often a result of frost-stirring of basic parent materials, and barren frost-scars can cover a large percentage of this unit. Both VIa and VIb may have up to 30 percent coverage of other vegetation types, mainly Moist Sedge - Prostrate Shrub Tundra (IVa) or Wet Sedge Tundra (III).	facies except in water tracks and near the foot and crest of the slope. Pergelic Cryochrepts are present on the few well-drained areas within this category.
VII.	Dark brown	Moist Dwarf Shrub, Tussock Sedge Tundra or Moist Tussock Sedge, Dwarf Shrub/Wet Dwarf Shrub Tundra Complex	VIIa. Moist Dwarf Shrub, Tussock Sedge Tundra (Upland Dwarf Shrub Tussock Tundra).--Upland tundra similar to Unit VI except here shrubs, mainly Salix pulchra (Diamond-leafed Willow) and Betula nana (Dwarf Birch), are dominant and may reach heights of up to 50 cm.	VIIa. Moist Dwarf Shrub, Tussock Sedge Tundra.--This unit is generally similar to land cover category VI in terms of soils.
			VIIb. Moist Dwarf Shrub, Tussock Sedge Tundra (Birch Tundra).--High-centered polygons and palsas with dwarf shrub communities dominated by Betula nana (Dwarf Birch) and Eriophorum vaginatum (Sheathed Cottongrass). These areas occur on high-centered polygons toward the southern end of the coastal plain and in low thermokarst drainage areas in the foothills. In some communities the birch is completely dominant and the cottongrass is absent. Other typical taxa in these sites are Rubus chamaemorus (Cloudberry), Ledum decumbens (Narrow-leafed Labrador Tea), Pedicularis labradorica (Labrador Lousewort), Vaccinium vitis-idaea (Mountain Cranberry); the mosses Sphagnum spp. dominate the ground layer with numerous Cladonia and Cladina lichens.	VIIb. Moist Dwarf Shrub, Tussock Sedge Tundra (Birch Tundra).--This unit occurs principally in the headwater areas of many small, often beaded drainages in the foothills area. In such areas thermal erosion combines with natural thermokarst to produce, by way of topographic reversal, high-centered polygons which may have a meter or more microrelief. Soils, which in uneroded portions of the headwater basins are Histic Pergelic Cryaquepts or Pergelic Cryohemists, are converted to (Sapric) Histic Pergelic Cryaquolls or Pergelic Cryosaprists by virtue of the better drainage afforded by the microrelief difference. A feature of headwater basins and some broad interfluves (unit IIIb) especially in the southern part of the foothills area are birch-covered peat plateaus

VII.	Dark brown	Moist Dwarf Shrub, Tussock Sedge Tundra or Moist Tussock Sedge, Dwarf Shrub/Wet Dwarf Shrub Tundra Complex	VIIc. Moist Tussock Sedge, Dwarf Shrub/Wet Dwarf Shrub Tundra Complex (Water-track Complex).--Hill slopes with numerous drainage channels. Tussock sedge, dwarf shrub tundra forms a complex with shrub communities in the water tracks. Height and density of the water-track shrubs vary, but the dominant taxon is generally Salix pulchra (Diamond-leafed Willow). Other important taxa in water tracks include Salix arctica (Arctic Willow), Betula nana (Dwarf Birch), Carex aquatilis (Water Sedge), Eriophorum angustifolium (Common Cottongrass), and other taxa typically found in Wet Sedge Tundra (IIIa).	(Palsas generally) that stand 0.5 to 1 m above the surrounding wet sedge tundra. The soils of these features are fibrous, Histic Pergelic Cryaquepts in which large volumes of segregation ice occur. Ice volumes increase with depth, and individual layers may be a meter or more thick. VIIc. Moist Tussock Sedge, Dwarf Shrub/Wet Dwarf Shrub Tundra Complex (Water-track Complex).--Differs from units VIa and VIb primarily because of the increased importance of water tracks, up to 30 percent of some slopes. These wet drainage lines run generally normal to the slope curving toward small streams. Wet sedge tundra with fibrous Histic Pergelic Cryaquepts occurs between short strangs (commonly curving downslope) that have a dwarf shrub vegetation; microrelief (drainage) contrasts are seldom sufficient to change the soil designation on the strangs. A shallow water table is always present in contrast to the adjacent sedge tussock (Pergelic Cryaquoll) tundra. Active layer thickness in the water tracks is greater than in the adjacent areas.
VIII.	Red	Shrub Tundra	VIIIa. Shrub Tundra (Non-complex).--South-facing slopes in the foothills and subalpine areas with communities dominated by dwarf and medium-height (up to 2 m tall) willows, birch, and/or alders. These sites are relatively warm and often rocky with a variety of microsites which contribute to great species diversity. Typical taxa include Salix spp. (Willow), Betula glandulosa (Shrub Birch), Alnus crispa (Mountain Alder), Lupinus arcticus (Arctic Lupine), Artemisia tilesii (Tilesius's Wormwood), A. arctica (Arctic Wormwood), Aconitum delphinifolium (Delphinium-leafed Monkshood), Delphinium brachycentrum (Northern Dwarf Larkspur), Potentilla fruticosa (Shrubby Cinquefoil), Bromus pumpellianus (Arctic Brome-grass), Equisetum arvense (Common Horsetail), Festuca altaica (Rough Fescue), Senecio lugens (Black-tipped Groundsel), Castilleja caudata (Pale Paintbrush), Carex microchaeta (Small-bristled	VIIIa. Shrub Tundra (Non-complex).--Common on steep slopes (from greater than 25 to 65 percent) in the southern part of the foothills and vegetation covered slopes in the alpine areas of the wildlife refuge. Such slopes are characterized by one or more forms of mass wasting, most commonly solifluction. Nonsoil and different kinds of soil are often juxtaposed, forming a mosaic of Pergelic Cryorthents, Histic Pergelic Cryaquolls (Pergelic and Histic Pergelic Cryaquepts where acid bedrock types are near the surface) and, in some cases, Pergelic Cryosaprists. Active layer thickness ranges widely about 1 m.

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	Color	Unit(s)	Description of vegetation and landcover units	Description of soils and landforms
VIII.	Red	Shrub Tundra	Sedge), Arnica frigida (Nodding Arnica), A. alpina (Alpine Arnica), Petasites frigidus (Lapland Butterbur), Saxifraga tricuspidata (Three-toothed Saxifrage), Vaccinium uliginosum (Bog Blueberry), V. vitis-idaea (Mountain Cranberry), Aster sibericus (Siberian Aster), Ledum decumbens (Narrow-leafed Labrador Tea) and Empetrum nigrum (Crowberry).	
			VIIIb. Shrub Tundra (Water-track Complex).--Similar to VIIc, except here the water-track shrub communities are dominant. This same unit may dominate some stream bottoms with extensive willow and sedge communities.	VIIIb. Shrub Tundra (Water-track Complex).--Same as for unit VIIc.
IX.	Violet	Partially Vegetated Areas	This unit includes a wide variety of communities in diverse habitats:	
			IXa. River Bars.--Partially vegetated river bars have a wide diversity of taxa that include Epilobium latifolium (River Beauty), Artemisia spp. (Wormwood), Salix spp. (Willow), Castilleja caudata (Pale Paintbrush), Hedysarum alpinum (Alpine Hedysarum), H. mackenzii (Mackenzie's Hedysarum), Arctostaphylos rubra (Bearberry), Oxytropis campestris (Yellow Oxytrope), Anemone parviflora (Northern Anemone), Equisetum arvense (Common Horsetail), Trisetum spicatum (Spiked Trisetum), Deschampsia caespitosa (Tufted Hairgrass), and Astragalus alpinus (Alpine Milk-vetch).	IXa. River Bars are included in the river island complex. Those that lack vegetation and lack soils are treated as riverwash deposits. Some bars or river islands, although subject to seasonal flooding and/or scouring, are partly covered with vegetation and receive additions of silts and fine sands. Such sites have Pergelic Cryorthent soils similar to those of Unit IVa but that differ from it in that the silt and/or sand upper horizon (over gravel) is generally less than 10 cm thick and lacks zones of organic materials.
			IXb. Alpine Tundra.--Many alpine tundra areas appear as partially vegetated because of the large amount of barren talus and rocks. The character of alpine tundra varies considerably, but the more completely vegetated areas have extensive moss mats (mainly Hylocomium splendens) with numerous prostrate shrubs, such as Dryas octopetala (Mountain Avens), Salix rotundifolia (Round-leafed Willow), Salix phlebophylla (Veiny-leafed Willow), and S. chamissonis (Chamisso's Willow), and herbs such as Carex michrocheata	IXb. Alpine Areas, above the solifluction slopes (unit VIII), are composed of partially vegetation covered, steep (greater than 50 percent) talus slopes and narrow crests. The flatter crests have sorted and unsorted stone nets and/or frost scars. The stable areas which support most of the vegetation have Pergelic Cryorthent soils and if sufficient fines are present Pergelic Cryochrepts. The soil pattern is one of Ruptic-Entic Pergelic Cryorthents and/or Cryochrepts, both with an organic surface horizon up to 5 cm thick.

IX.	Violet	Partially Vegetated Areas	(Small-bristled Sedge), Geum glaciale (Glacier Avens), Saxifraga bronchialis (Spotted Saxifraga), S. davurica (Davurian Saxifrage), S. tricuspidata (Three-toothed Saxifrage), S. serpyllifolia (Thyme-leafed Saxifrage), and many lichens including Cladina spp., Cladonia spp., Nephroma expallidum, Cetraria spp., Dactylina arctica, and Sphaerophorus globosus.	
			IXc. Sorted Stone-nets.--Some extensive sorted polygons occur in the Jago and Okpilok drainages. These contain rocks covered by lichens such as Umbillicaria spp., Lecanora spp., Lecidea spp., Rhizocarpon spp., and Alectoria minuscula, etc.	IXc. Sorted Stone-nets having large block-bordered polygons are noted in the southern parts of the Jago and Okpilok drainages. In some cases Ruptic-Entic Pergelic Cryochrepts and/or Cryaquepts are developed in the finer textured materials in the centers of the polygons.
			IXd. Beaches.--Some coastal beaches and mud flats are sparsely vegetated with Carex subspathacea (Hoppner Sedge) and Puccinellia phryganodes (Creeking Alkali-grass) and other taxa similar to Wet Saline Tundra (IIId).	IXd. Beaches generally do not have sufficient stability to develop soils. In the few cases, when they are developed under sedges, they are Cryorthents.
			IXe. Sand Dunes.--Dune communities occur in the delta of the Canning River. Species are similar to those occurring on river bars (IXa). The more sparsely vegetated dunes are dominated by Elymus arenarius. More stable dunes have communities similar to the Dryas river terrace community (IVb).	IXe. Sand Dunes are not abundant in the wildlife refuge, occurring mostly in the delta regions of the Canning and Jago Rivers. Where sufficient vegetation exists to stabilize or partially stabilize them, the soils are Pergelic Cryopsamments. Permafrost is greater than 1 m. Wet sandy materials between the dunes have Pergelic Cryaquept soils. No soil is recognized on dunes lacking vegetation.
X.	Black	Barren Gravels or Rock	X. Barren Gravels or Rock.--Light-colored barren gravel or rock occurs in a variety of places including: bare river gravels, gravel and sand spits, alpine barrens (particularly dolomite), and cultural barrens such as the runway and roads at Barter Island. Some gravelly ridge tops in the foothills are classed as this unit. These areas actually have a quite rich but sparse flora that includes Potentilla biflora (Two-flowered Cinquefoil), Dryas octopetala, Artemisia arctica (Arctic Wormwood), Castilleja caudata (Pale Paintbrush), Pedicularis verticillata (Whorled Lousewort), Polemonium	X. Barren Gravels or Rock areas are mostly included in the river island complex and do not have soils (river wash deposits Unit IVb). Water tables reflect river water level, and permafrost is deep or absent. Some gravel barrens and rock outcrop areas, especially those occurring on uplands, do not have a water table, and ice-rich permafrost, if present at all, lies at depths greater than 1 m.

Table III-2.--Preliminary descriptions of vegetation and soils within the Landsat landcover categories for the Arctic National Wildlife Refuge--Con.

	Color	Unit(s)	Description of vegetation and landcover units	Description of soils and landforms
X.	Black	Barren Gravels or Rock	boreale (Boreal Jacob's Ladder), and other taxa similar to gravel river bars (IXa). The gravels in the rivers flowing out of the limestone Sadlerochit Mountains (the Katakturuk, Tamayariak, and Marsh Creek) are lighter colored than the gravels of the Canning, Sadlerochit, Hulahula, Okpilok, and Jago Rivers.	
XI.	Gray	Barren Mud or Wet Gravels	XI. Barren Mud or Wet Gravels.--This unit has a somewhat darker spectral signature than the previous category (X). It includes extensive barren mud in the deltas of rivers, wet gravels in the rivers and beaches, and some darker dry gravels, mainly in those rivers not flowing out of the Sadlerochit Mountains. Some dark-colored barren rocks in the mountains are also classed as this unit.	XI. Barren Mud or Wet Gravels are within the riverine system and the delta areas, although wet gravels may occasionally be found on flat uplands and beaches. In most cases shallow water tables and a thick active layer are present. Soils are generally not recognized. In cases where extensive mottling occurs in the profile, Pergelic Cryaquepts may be designated.
XII.	White	Ice	XII. Ice.--River icings (Aufeis) occur in the braided stream channels of most of the larger rivers.	

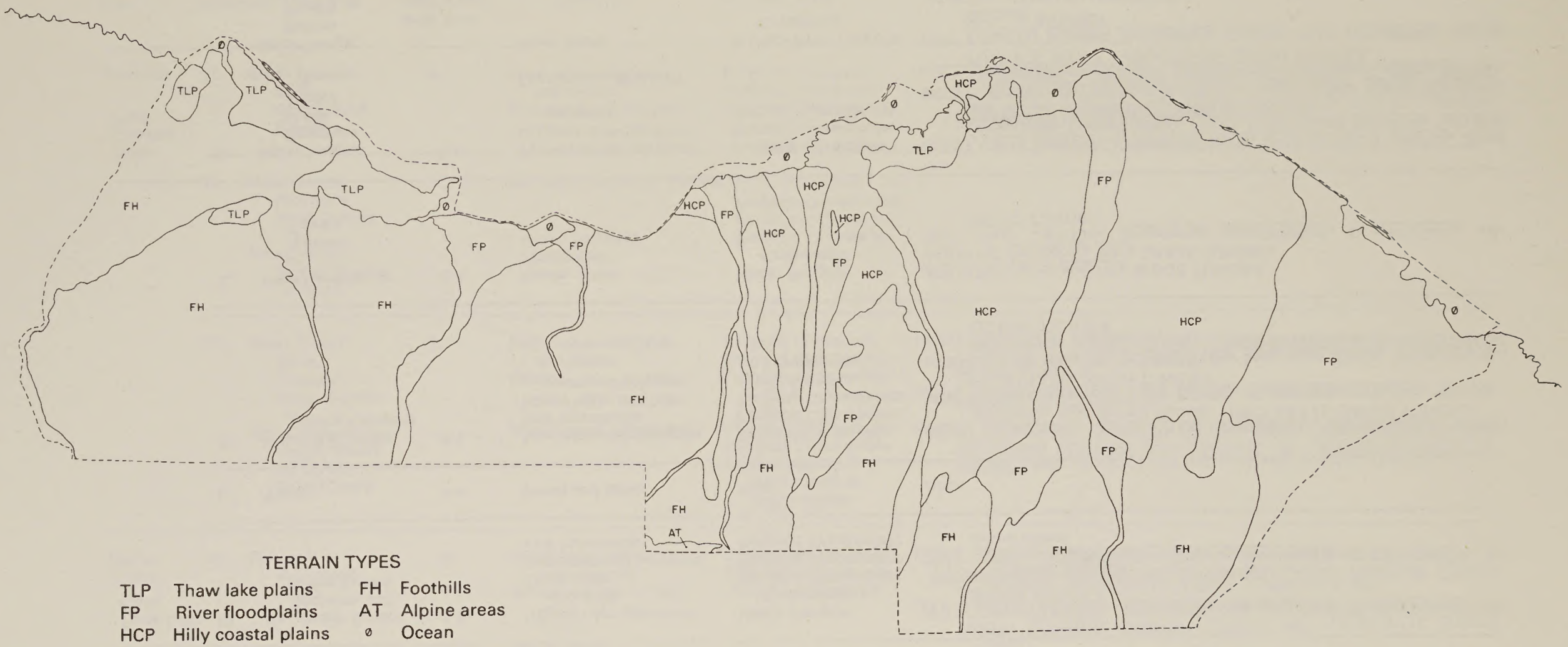


Figure III-3.--Terrain types map.

Table III-3.--Summary of principal landcover categories within the terrain types of the Arctic National Wildlife Refuge study area, with associated landforms, soils, and vegetation

Terrain type	Principal Landsat landcover categories		Percent of total ANWR study area	Principal landforms	Principal soils	Principal vegetation communities
Thaw Lake Plain	III.	Wet Sedge Tundra (includes wet saline tundra	1.4	Disjunct low-centered polygons Strangmoor Low-centered polygons Low hummocks	Histic Pergelic Cryaquepts Pergelic Cryaquepts Pergelic Cryohemists Pergelic Cryofibrists	WET Carex aquatilis, Eriophorum angustifolium, Drepanocladus spp. SEDGE TUNDRA AQUATIC Carex aquatilis SEDGE TUNDRA WET Carex subspathacea, Puccinellia phryganodes SEDGE TUNDRA (in saline areas)
	I.	Water	0.6	Ponds and lakes	None	None
	IV.	Moist/Wet Sedge Tundra Complex	0.4	Low-centered polygons Low hummocks Mixed high- and low-centered polygons	Pergelic Cryaquolls Pergelic Cryaquepts Pergelic Cryosaprists Histic Pergelic Cryaquepts	MOIST Eriophorum triste, Dryas integrifolia, Tomenthypnum nitens, Thamnolia subuliformis SEDGE - PROSTRATE SHRUB TUNDRA MOIST Carex aquatilis, Salix pulchra, Campylium stellatum SEDGE - PROSTRATE SHRUB TUNDRA MOIST Carex spp., Dryas integrifolia, Salix rotundifolia, Dicranum sp., Ochrolechia frigida SEDGE - PROSTRATE SHRUB - CRUSTOSE LICHEN TUNDRA
	II.	Pond Complex or or Aquatic Tundra	0.3	Ponds, lakes Strangmoor Mixed polygons	Histic Pergelic Cryaquepts Pergelic Cryaquepts Pergelic Cryofibrists Pergelic Cryohemists	AQUATIC Carex aquatilis SEDGE TUNDRA AQUATIC Arctophila fulva GRASS TUNDRA WET Carex aquatilis, Eriophorum angustifolium, Drepanocladus spp. SEDGE TUNDRA
Hilly Coastal Plain	V.	Moist Sedge, Prostrate Shrub Tundra or	8.4	Flat-centered polygons Disjunct low-centered polygons Featureless, low hills	Pergelic Cryaquolls Pergelic Cryaquepts Pergelic Cryofibrists	MOIST Carex bigelowii, Eriophorum triste, Salix arctica, S. pulchra, Dryas integrifolia, Tomenthypnum nitens, Hylocomium splendens, Cetraria spp. SEDGE -PROSTRATE SHRUB TUNDRA MOIST Eriophorum vaginatum, Dryas integrifolia, Carex bigelowii, Tomenthypnum nitens, Hylocomium splendens, Cetraria spp. TUSSOCK SEDGE - PROSTRATE SHRUB TUNDRA
		Moist Sedge/ Barren Tundra Complex		Frost scars	Ruptic-Entic Pergelic Cryaquolls	DRY Petasites frigidus, Arctagrostis latifolia, Salix rotundifolia, Juncus biglumis BARREN
	IV.	Moist/Wet Sedge Tundra Complex	7.3	See same landcover heading for Thaw Lake Plain		
	III.	Wet Sedge Tundra Complex	5.1	See same landcover heading for Thaw Lake Plain (excludes Wet Saline Graminoid Tundra)		

Table III-3.--Summary of principal landcover categories within the terrain types of the Arctic National Wildlife Refuge study area, with associated landforms, soils, and vegetation--Con.

Terrain type	Principal Landsat landcover categories	Percent of total ANWR study area	Principal landforms	Principal soils	Principal vegetation communities
Foothills	VI. Moist Tussock Sedge, Dwarf Shrub Tundra	24.1	Featureless hillcrests and slopes Flat-centered polygons	Pergelic Cryaquolls Pergelic Cryaquepts Pergelic Cryosaprists	MOIST Eriophorum vaginatum, Betula nana, Salix pulchra, Ledum decumbens, Vaccinium uliginosum, V. vitis-idaea, Sphagnum spp., Hylocomium splendens, Cladonia spp. TUSSOCK SEDGE - DWARF SHRUB TUNDRA
	V. Moist Sedge, Prostrate Shrub Tundra or Moist Sedge/ Barren Tundra Complex	13.7	See same landcover heading for Hilly Coastal Plain		
	VII. Moist Dwarf Shrub, Tussock Sedge Tundra or Moist Tussock Sedge, Dwarf Shrub/Wet Dwarf Shrub	3.1	Featureless hillcrests and slopes Palsas	Pergelic Cryaquolls Pergelic Cryaquepts Pergelic Cryosaprists	MOIST Betula nana, Salix pulchra, Eriophorum vaginatum, Vaccinium spp., Ledum decumbens, Sphagnum spp. DWARF SHRUB - TUSSOCK SEDGE TUNDRA MOIST Betula nana, Ledum decumbens, Sphagnum spp. DWARF SHRUB TUNDRA
			Water-track complexes	Pergelic Cryohemists Pergelic Cryofibrists Histic Pergelic Cryaquepts in water tracks	MOIST Eriophorum vaginatum, Betula nana, Salix pulchra, Ledum decumbens, Vaccinium spp., Sphagnum spp., Hylocomium splendens, Cladonia spp. TUSSOCK SEDGE - DWARF SHRUB TUNDRA
Alpine Tundra	IX. Partially Vegetated Areas	.02	Solifluction lobes and terraces Sorted and non-sorted stone nets and stripes Block fields Talus slopes	Pergelic Cryorthents Pergelic Cryochrepts Pergelic Cryaquepts	MOIST Carex michrochaeta, Dryas octopetala, Salix rotundifolia, S. chamissonis, Saxifraga bronchialis, Hylocomium splendens, Cladina spp. SEDGE - PROSTRATE SHRUB - FORB TUNDRA DRY Dryas octopetala, Salix reticulata, Carex michrochaeta, Geum glaiale, Rhytidium rugosum, Cetraria spp. PROSTRATE SHRUB TUNDRA DRY Umbilicaria spp, Lecidea spp., Rhizocarpon spp. LICHEN-BARREN TUNDRA
	X. Barren Rock	.009	Talus slopes or Bedrock	None	DRY Umbilicaria spp., Lecidea spp., Rhizocarpon spp., LICHEN-BARREN TUNDRA

Table III-3.--Summary of principal landcover categories within the terrain types of the Arctic National Wildlife Refuge study area, with associated landforms, soils, and vegetation--Con.

Terrain type	Principal Landsat landcover categories	Percent of total ANWR study area	Principal landforms	Principal soils	Principal vegetation communities
River Flood Plains	III. Wet Sedge Tundra	8.4	See same landcover heading for Thaw Lake Plain		
	IV. Moist/Wet Sedge Tundra Complex	6.1	See same landcover heading for Thaw Lake Plain		
	or Dry Prostrate Shrub - Forb Tundra		River terraces with reticulate pattern Featureless, stabilized dunes	Pergelic Cryopsamments	Dryas integrifolia, Salix reticulata, Astragalus alpinus, Equisetum arvense, Carex membranacea, Oxytropis nigrescens, Distichium capillaceum PROSTRATE SHRUB - FORB TUNDRA
	V. Moist/Wet Sedge - Prostrate Shrub Tundra or Moist Sedge/ Barren Tundra Complex	4.2	See same landcover heading for Hilly Coastal Plain		
	IX. Partially Vegetated Areas	1.25	River islands, bars and terraces, deltas Sand dunes	Pergelic (Fluventic)* Cryorthents Pergelic Cryopsamments	DRY Salix alaxensis, Salix spp., Arctostaphylos rubra, Hedysarum alpinum, Castilleja caudata, Oxytropis campestris, Astragalus alpinus MEDIUM SHRUB - FORB - BARREN TUNDRA DRY Epilobium latifolium, Artemisia arctica, Castilleja caudata, Androsase chamaejasme, Bromus pumpellianus, Festuca rubra FORB - GRASS - BARREN TUNDRA DRY Dryas integrifolia, Oxytropis nigrescens, Salix ovalifolia, Artemisia borealis PROSTRATE SHRUB - BARREN TUNDRA
	X. Barren gravels or mud	2.06	River channels	Pergelic Cryorthents	None

* Unofficial taxonomic name.

Figure III-4.--Oriented thaw-lake topography in the delta of the Canning River. The lakes here show only weak orientation. Photograph by D. A. Walker, Institute of Arctic and Alpine Research, University of Colorado.

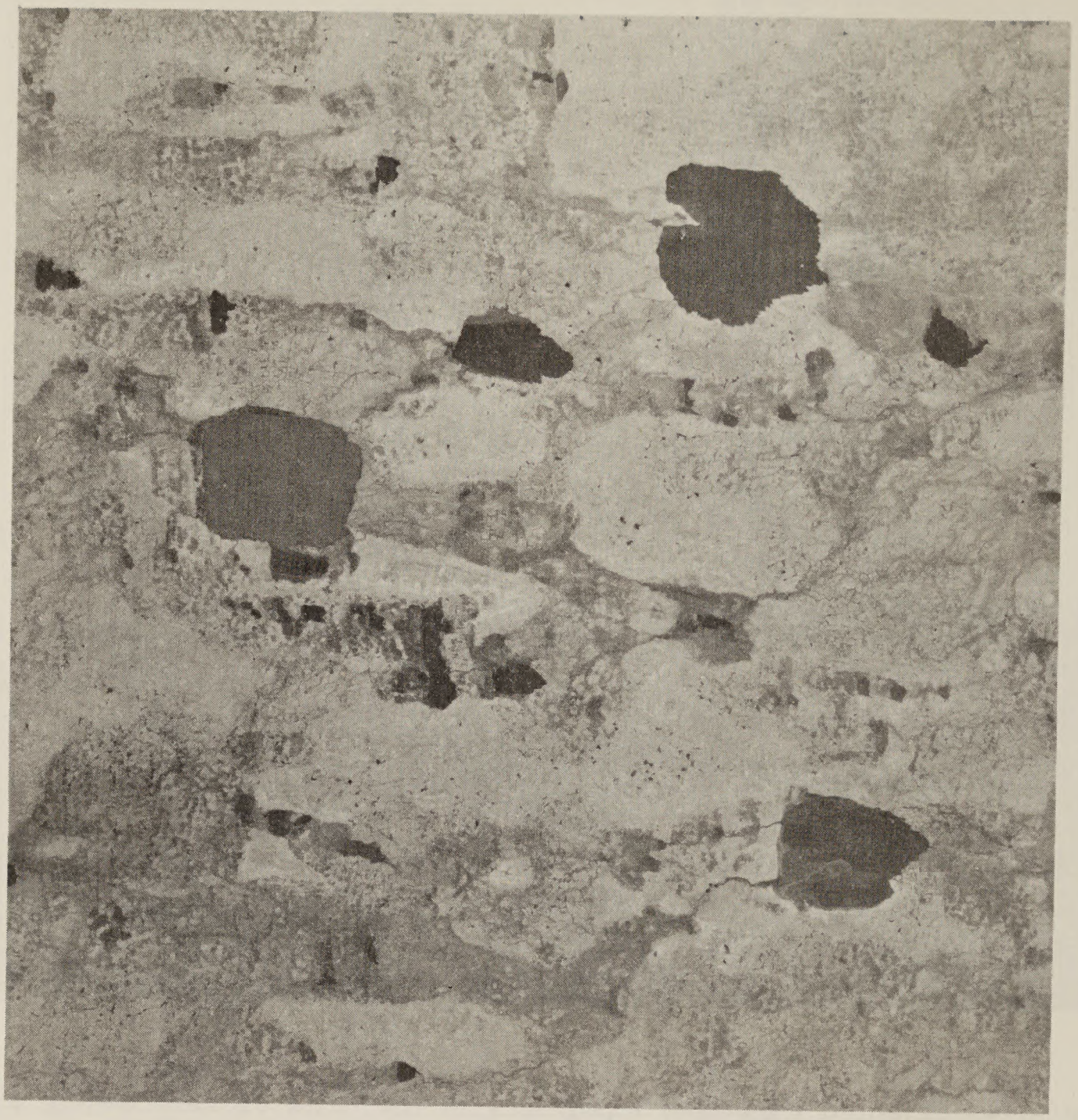


Figure III-5.--Vertical aerial photograph (scale 1:18,000) of gently rolling coastal plain terain in the vicinity of the Niguanak River, southeast of Barter Island. Numerous upland surfaces are oriented in an east-west direction. Relief associated with these features is less than 10 m. Note the large number of thermokarst pits on the upland surfaces, indicating high amounts of ground ice.

This complex covers 37.5 percent of the hilly coastal plain type. Moist/Wet Sedge Tundra complex is also important, covering 33.5 percent of this terrain type. The depressions between ridges contain thaw-lakes and wet tundra. Stream drainages are well defined and have large expanses of relatively well drained terrain associated with them.

Foothills

Foothills cover about 45 percent of the study area. Between the Canning and Sadlerochit Rivers, an east-west distance of about 75 km, low foothills rise from Camden Bay to the base of the Sadlerochit Mountains (fig. III-6), 30 to 55 km from the seacoast. The hills in this region are as high as 380 m and are interspersed with the drainages of the Tamayariak River, Katakturuk River, Marsh Creek, Carter Creek, Itkilyariak Creek, and the Sadlerochit River. The crests of several hills, particularly in the vicinity of the Katakturuk River, have barren gravel outcrops (fig. III-7). East of the Sadlerochit River the foothills are farther from the coast. In the vicinity of the Jago River, the widest part of the ANWR coastal plain is about 40 km, with another 20 km of foothills to the refuge-wilderness boundary.

Parallel and subparallel water tracks are commonly present, giving the slopes a decidedly ribbed appearance. These water tracks are shallow, vegetated drainage channels that conduct snowmelt waters, and perhaps subsurface waters as well, during the thaw season. Strangmoor are often found in the channels, suggesting slow mass movement of the saturated soil column. Vegetation is characterized by tussocks of sheathed cottongrass. Willow or birch commonly are a significant component of the vegetation but are sparsely distributed. Where bedrock is very close to the surface, frost-scars and/or patterned lag gravel may comprise as much as 70 to 80 percent of the surface. Vegetation in the foothills is predominantly Moist Tussock Sedge, Dwarf Shrub Tundra (app. B, figs. B-23 and B-24). Vegetation in the water tracks is commonly dominated by dwarf shrubs, mainly dwarf birch and diamond-leafed willow.

Habitat values of foothill areas are not well understood. Caribou apparently utilize these areas heavily for foraging and calving grounds. Moose and muskoxen favor the drainages where willows are abundant.

Alpine Tundra

Alpine terrain (fig. III-8) consists of only a few square kilometers in the study area (about 0.05 percent), mostly above 600 m elevation, in the vicinity of Sadlerochit Spring (fig. III-9), at the northeastern end of the Sadlerochit Mountains. Crests here range around 1,250 m. Sadlerochit Spring is of special interest because of poplars and other disjunct plant species that occur (Murray, 1979).

Vegetation communities in these areas are complex and are interspersed with unvegetated rocks and talus slopes. The character of the well-vegetated slopes varies considerably, but the more completely vegetated areas have extensive moss mats with numerous prostrate shrubs, such as mountain avens, prostrate willows, and small forbs. Limestone areas are of particular interest because of the presence of unique assemblages of plants, such as the bryophytes associated with wet limestone seeps (Brown and Berg, 1980; Steere and Murray, 1976).

Figure III-6.--Foothills terrain south of Camden Bay. Upland surfaces are dominated by Tussock Sedge-Dwarf Shrub Tundra. Photograph by D. A. Walker, Institute of Arctic and Alpine Research, University of Colorado.

Figure III-7.--Barren gravel outcrops along the Katakturuk River. Photograph by D. A. Walker, Institute of Arctic and Alpine Research, University of Colorado.

Figure III-8.--Partially vegetated areas, Alpine Tundra. This area is on the northern flank of the Sadlerochit Mountains. Photograph by D. A, Walker, Institute of Arctic and Alpine Research, University of Colorado.

Figure III-9.--Sadlerochit Spring. This area is a particularly valuable site because of unusual plant communities associated with the spring. Photograph by D. A. Walker, Institute of Arctic and Alpine Research, University of Colorado.

River Flood Plains

River environments (about 25 percent of the study area) are among the most complex in the ANWR study area (fig. III-10). They include the barren deltas and braided channels of the larger rivers, the terraces and alluvial areas associated with old river channels, and the delta formations at the base of the foothills that possibly represent an ancient sea level.

Riverine systems consist of the active channel and usually one or more terraces. The majority of the rivers within the ANWR have braided channels ranging in width from about 1 to 4 km. Most of the diamond-shaped islands between channels are inundated sporadically each year during the period of melt-off (usually late May to early June). Two types of islands occur--those consisting of unvegetated gravels and gravelly sands (silts in the delta region) with no soil development, and those removed from the main channel or elevated slightly above the normal high-water mark because of channel cutting. These latter islands have widely ranging vegetation coverage, depending upon the extent and frequency of inundation. The soils development on these islands consists of silt, silt loam, loam and fine sandy loam over gravel and gravelly sand soils.

Land cover associated with river systems ranges from totally barren river gravels and mud to tundra that is indistinguishable from that in nonalluvial areas. The braided channels are subject to intense disturbance during spring breakup. In addition, meandering streams and braided rivers are constantly changing their channels. Slightly more stable areas are often only partially vegetated but may contain a wide variety of taxa, making them among the most floristically rich sites in the region (app. B, fig. B-29). Willows are common on partially vegetated gravel bars and may form fairly extensive thickets; however, these thickets are not nearly so extensive as the riparian willow communities found farther west along the Sagavanirktok, Kuparuk, and Colville Rivers. This relatively limited supply of riverine willow within the study area is of significance to wildlife species such as muskoxen and ptarmigan. Smaller streams and quieter interchannel areas of the larger rivers have lush sedge and willow stands (app. B, fig. B28). Willow height varies with the amount of winter snow cover and the summer temperature regime. Willows near the coast are mostly prostrate, whereas, near the southern boundary of the study area, shrubs can exceed 2 m in height.

Dry terraces just above the main braided channels often have distinctive Dry Prostrate Shrub, Forb Tundra (app. B, fig. B-30). These communities are fairly extensive, especially along the Canning River. The dry soils of these terraces are excellent habitat for arctic ground squirrels, and arctic and red foxes. They also are favorite hunting grounds for brown bears.

Numerous areas of river icings occur in braided sections of the larger rivers where the channel freezes to the bottom during most winters (figs. III-11, III-12). These icings persist in the summer and are important insect relief areas for caribou.

Figure III-2.--Physiographic divisions of northeastern Alaska. Slightly modified, after Wahrhaftig, 1965.

study of flood characteristics of streams in the ANWR found that maximum evident flood-peak discharge rates averaged about 40 cubic feet per second per square mile.

The size and relative streamflow of the principal rivers within the ANWR study area are summarized in table III-1, which lists the major rivers across the eastern Arctic Slope.

The primary cause of floods in the ANWR is rapid spring snowmelt. The height of the floodflow is significantly increased by the presence of ice jams during spring breakup. In spring (May and June), melt water begins to accumulate and flow over the surface of the inland ice and on the deltas. As the river ice fractures and breakup begins, melt water combines with the increasing downstream flow of freshwater to rapidly flush the seawater from the lower rivers and deltas. Wide variations exist in the magnitude of spring flooding, as well as the likelihood of summer flooding, depending on whether river systems head in snowfields or flow through large lakes, as in the case of the Sadlerochit. As breakup continues, extensive flooding permits rapid movement of ice toward the sea, where floodwater and block ice move onto and beneath the sea ice. Sediment loads are at their peak during flooding, and considerable deposition (several centimeters) of fine material may occcur on the sea ice surface. The freshwater and sediments are soon drained through cracks and holes in the sea ice which develop with changes in the thermal regime (H. J. Walker, 1974). Following breakup, flooding drops off rapidly. Due to the low summer rainfall, there is little chance of summer flooding, but fall storms in the mountains can cause high water conditions.

Lakes are not a conspicuous hydrologic feature in the ANWR study area. Shallow thaw-lakes do occur, however, along the coast and adjacent to the main river deltas. They are most common on the broad, nearly level deltas of the Canning and Hulahula Rivers. Nearly all of the lakes are less than 1 square mile in area. Most are less than 6½ feet deep and freeze to the bottom in winter. There are no glacial lakes within the study area.

Widespread permafrost limits the occurrence of ground water in the ANWR. There are no water wells in the ANWR, but there are several springs of considerable significance. Sadlerochit Spring discharges from bedrock on a hillslope at the eastern end of the Sadlerochit Mountains. This spring maintains a nearly steady discharge of 37 cubic feet per second at a temperature of about 55°F (13°C). This amounts to about 24 million gallons of water a day. Shublik Spring, located outside the study area, influences the water supply of the Canning River. Large springs also occur on the Hulahula, Okerokovik, Aichilik, and Kongakut Rivers, and small springs occur on several other rivers.

Water availability on ANWR varies seasonally. Springs are the most obvious source of winter water. Water stored as snow or ice through the winter and early spring is frequently used as a source of water supply. A lake is used for water supply at Barter Island, but its quality becomes poor in late winter because of freeze concentration of dissolved solids. At that time, lake ice is usually melted for water use.

Turbidity resulting from suspended sediments is the most visible impairment of water quality. Suspended-sediment concentrations are highest in the major streams and rivers during spring breakup and during periods of high summer flow.

Table III-1.--Size and relative streamflow of the principal rivers, eastern Arctic Slope

(Table modified from Childers and others, 1977)

	BANKFULL CHANNEL						MAXIMUM EVIDENT FLOOD		
Stream site	Streambed material	Slope (ft/ft)	Width (ft)	Mean depth (ft)	Max depth (ft)	Discharge (ft^3/s)	Width (ft)	Discharge (ft^3/s)	Unit runoff ($ft^3/s/mi^2$)
Colville River 70°09'56" 150°05'50"	fine gravel	0.00056	2,240	25.2	57	683,000	2,230	600,000	29.0
Shaviovik River 70°05'07" 147°16'30"	coarse cobble	0.0012	1,510	4.2	7	22,000	1,510	22,000	13.0
Canning River 69°50'38" 146°27'10"	large cobble	0.0012	960	6.9	14	31,000	1,150	53,000	28.3
Katakturuk River 69°52'25" 145°27'10"	coarse gravel	0.0064	680	3.7	7	17,000	670	10,000	43.9
Marsh Creek 69°47'32" 144°49'00"	coarse gravel	0.0148	560	3.4	6	14,000	280	500	1.9
Sadlerochit River 69°39'13" 144°12'10"	boulders	0.0062	280	4.5	7	11,000	280	11,000	20.8
Hulahula River 69°41'47" 144°12'10"	coarse gravel	0.0050	250	7.2	9	23,000	240	10,000	14.7
Jago River 69°37'02" 143°41'06"	boulders	0.0132	180	5.9	7	14,000	180	14,000	43.6
Okerokovik River 69°42'07" 143°14'23"	coarse gravel	0.0033	590	3.4	7	10,000	360	2,300	13.6
Aichilik River 69°35'23" 142°58'03"	coarse gravel	0.0054	820	5.5	8	33,000	817	27,000	48.0
Egaksrak River 69°32'05" 142°41'05"	large cobble	0.0093	560	2.4	6	9,000	560	9,000	41.9
Ekaluakat River 69°34'35" 142°18'38"	medium gravel	0.0109	730	3.1	6	23,000	860	27,000	185.0
Kongakut River 69°30'54" 142°42'34"	coarse gravel	0.0058	2,770	4.6	9	98,000	2,770	98,000	79.0
Turner River 69°35'56" 141°24'10"	medium gravel	0.0038	160	1.7	6	1,300	170	1,500	29.4

During low-flow periods, all the streams are essentially clear. Some of the shallow lakes also become turbid during the summer, when wind and wave action disturb bottom sediments. Aside from periods of turbidity, the water in most rivers and lakes is virtually colorless. Tea-colored waters, resulting from high concentration of dissolved organic materials, occur in some of the small tundra streams and lakes. Some rivers are turbid throughout the summer as a result of the their glacial origin (Aichilik, Jago, Okpilak, Hulahula, Canning).

Water quality in lakes and streams is reduced in winter because of freeze concentration. The amount of concentration depends on the ratio of water to ice in a water body when maximum ice thickness is reached. Water in shallow lakes and river pools that freeze nearly to the bottom can become unpotable in late winter.

Dissolved oxygen in water is at or near saturation in the lakes and streams of the ANWR during summer, but levels of dissolved oxygen can be severely depressed under ice cover in winter, owing to the lack of reaeration and extended darkness that limits photosynthetic activity. Low dissolved-oxygen contents are most prevalent in water bodies that freeze nearly to the bottom.

The water quality of springs in the ANWR is very good. The water is colorless and odorless, has little taste, is fairly low in total dissolved solids, and is fairly constant in temperature, chemistry, and discharge throughout the year.

Climate and Meteorology

The climate of the ANWR study area is in the Arctic zone. Summers are short, cool, and generally cloudy. Temperatures of the warmest month (July) average about 5°C, with maximum temperatures rarely exceeding 30°C. Winters are very cold, with temperatures of the coldest month (February) averaging about -20°C. Extreme lows frequently drop below -40°C. High surface winds common throughout the year result in wind chill factors well below actual temperatures.

The Arctic coast experiences frequent cloudiness and fog, and high winds. At Barter Island, total cloud cover occurs 54 percent of the year, and fog may be expected at least 115 days. Inland, clear skies are more common and winds are variable and temperature ranges and extremes tend to be greater. This contrast is intensified during the late summer and fall months when there is open water along the coast, although even in winter when the Arctic Ocean is frozen over, air temperatures reflect some marine influence.

Based on precipitation alone, the Arctic Coastal Plain can be considered arid, with average annual rainfall less than 25 cm (10 inches), including the water equivalent of 30-120 cm of snowfall. Summer rainfall accounts for most of the total precipitation. Snowfall may occur in any month, with heaviest snowfall usually occurring in October. Snow deeper than 1 foot (30 cm) persists for many days each winter throughout the ANWR.

Almost continuous winds move and redistribute snow, causing bare or nearly bare ridgetops and drifted valleys. At present, little information is readily available to determine the distribution of snowfall and wind effects upon the removal/accumulation of snow cover in the study area. An inference on the nature of the dynamics of the snow cover for the study area can be drawn from the report

by Swan and others (1978). The report provides an example of the snow depth from the coast to mountain gradient in the NPR-A area. Benson and others (1975) and Everett and Parkinson (1977) reported an average April wind-packed snow depth of 30 to 40 cm for the Prudhoe Bay area. The snow pack ranges anywhere from a few centimeters to as much as 20 cm of recrystallized, low density "depth hoar" with an upper layer of higher density wind-packed snow.

In the open landscape of the tundra, the ever-blowing winds constantly shift dry snow from place to place. In the cold air, and especially in the areas where large amounts of moisture are increased through combustion of hydrocarbons, the moisture in the air precipitates out as thin needle-shaped crystals. Even with weak winds, needles colliding with one another or with the ground result in extremely fine snow dust which fills the air and provides the sinuous streams of snow dust. As wind strength increases, a fine snowy fog is created giving rise to the commonly encountered limited visibility and "whiteouts."

The typical snow cover cross section on the tundra commonly shows a succession of hard wind-packed layers overlying a coarse granular layer with little cohesion ("depth hoar") (Keller, 1972). The depth hoar results from the combination of initially loose freshly fallen snow becoming overlaid by a hard wind-packed layer, and by subsequent upward movement of water vapor along the temperature gradient, from the warmer ground surface to the colder snow surface. One or more ice layers can form in the snow pack as the result of the thaw, downward percolation of meltwater, and subsequent freezing. Ice layers tend to make the snow pack dense and cohesive.

The prevailing easterly winds at Barter Island average about 13 knots windspeed. Westerly winds can be much more intense than the prevailing easterlies and have been measured as high as 80 knots at Barter Island.

Wind effects are dramatically portrayed along the shoreline and shoreline bluffs. Seaward-facing bluffs along the shore show the eroding effects of winds through gullying and stripping of tundra vegetation. Wind erosion is dramatically displayed by the extensive east-west erosion scars of the active sand dunes of the Canning, Hulahula, Okpilak, and Jago River Deltas. Coastal bluff crests and their soils undergo natural profile disruption by mixing from frost action and by wind abrasion. Because they are exposed, bluff crests and their soils are commonly snow-free during winter. The natural instability of the bluff faces make them very susceptible to outside disturbances, especially those that induce channeling or ponding of melt waters.

Few, if any, air quality measurements have been made in the ANWR. However, since few local pollution sources exist, it is reasonable to assume that air quality is good. Recent evidence indicates that some pollution does occur from distant sources, most likely located in Eurasia. The amount of particulate matter in the air, however, may be locally high, especially during dry summer periods, because of wind-borne dust from beaches, and bars, and other bare areas, such as riverbanks and flood plains. Smoke from tundra fires in the ANWR may, on rare occasion, cause some localized air pollution. Winds occasionally transport smoke to the area from more distant fires south of the Brooks Range, mainly during the summer months.

Geologic Processes

The following description of certain geologic processes emphasizes those natural phenomena that directly pertain to evaluating environmental impacts that could result from seismic oil and gas exploration. During the 8- to 9-month winter season most of the geologic processes described here are inactive because the ground is frozen, surface streamflow is practically nonexistent, and the Beaufort Sea is covered with ice. However, disturbance of the vegetation mat during the winter season can result in serious environmental problems that will manifest themselves during subsequent summer months.

With regard to seismic exploration activities, permafrost degradation is, by far, the most critical geologic hazard. In addition, it exacerbates most slope stability and erosion problems.

In the study area, the character of the geologic materials, along with the elevation, interrelated slope, and drainage conditions, determines the character of the permafrost and, therefore, the potential severity of permafrost degradation or thawing, the potential for landslides and mass wasting, and the susceptibility of materials to erosion.

Permafrost Degradation

Permafrost is defined as soil, rock, or any other earth material whose temperature remains below 0°C (32°F) continuously for 2 or more years (Muller, 1943, p. 3). Most of the permafrost in Alaska has been in this frozen condition for many thousands of years; some is slowly degrading (growing thinner), but some is aggrading (growing thicker) today. The factors that control the distribution of permafrost also control its temperature, which varies markedly with depth, latitude, and geologic and topographic setting.

Even in the coldest parts of Alaska, a thin layer of ground, the "active layer," thaws every summer and separates the permafrost from the ground surface. The thickness of the active layer depends upon moisture contact and the capacity of the surface material to protect the underlying permafrost from summer heat. It can vary locally from one-half foot to 5 feet or more and can change dramatically when the surface is disturbed.

During winter, thermal contraction of the ground surface in northern Alaska causes it to crack in a pattern resembling mud cracks, only much larger (Lachenbruch, 1962). Summer melt water pours into these cracks in the permafrost and freezes, forming a vertical network of intersecting ice veins. As centuries pass, repeated cracking at these sites of weakness causes these veins to grow into a network of massive wedges of ice, often tens of feet deep, several feet wide at the top, and separated from one another by 100 feet or more. Ice wedges are sometimes indicated by polygonal ground surface markings, but more often they are not. Other forms of ice, including lenses of all sizes and interstitial forms, are also common in permafrost.

Disturbance of the ground surface can cause thawing of permafrost and slope failures. Such effects can be caused by damage to the organic surface layer, by disrupted surface drainage, or by gravel pads. Such modifications can have a critical effect on the ground surface, but it may take several years before the effects are fully manifest.

The primary problems resulting from thawing of permafrost relate to potential loss of strength and volume (Ferrians, Kachadoorian, and Greene, 1969). In ice-rich material, this can cause severe differential settlement or liquefaction of the soils. Such effects are often irreversible and under adverse conditions may be self-perpetuating and difficult to predict.

The ANWR study area is within the continuous permafrost zone. In northern Alaska, where the climate is extremely cold, permafrost forms a virtually continuous layer to depths of several hundred feet beneath the surface and locally to as much as 2,000 feet beneath the surface.

The unconsolidated materials in the study area that are not frozen year-round at shallow depths are the unvegetated active flood-plain deposits (sandy gravel and sand) which are present in the larger drainageways. The depth to which these materials are thawed depends upon the size of the drainageway and the amount of water flowing in it. Also, certain spits and bars in the coastal area are free of permafrost near the surface. The large amount of heat in the water keeps these materials thawed during the summer months. The extensive vegetated terraces that border the active flood plains also are underlain by sand and gravel deposits, but these deposits generally are overlain by several feet of sandy silt or fine silty sand and an organic mat of peat. These deposits commonly contain ice and are frozen year-round, except for a thin active layer.

Most of the low-lying areas, which comprise the bulk of the study area, are underlain by extremely ice-rich fine-grained deposits. Ice-wedge polygons are the dominant form of ground ice in this area (Leffingwell, 1915); however, other forms of ground ice are also common. Well-indurated bedrock, which is limited in the area, has few voids and, consequently, does not contain large quantities of ground ice.

Landslides and Mass Movement

Landslides and mass movements (the downslope movement of soil and/or rock material en masse under the direct influence of gravity) can occur on very gentle slopes but are more common on steep slopes. Landslide movement is very rapid and occurs as falls, flows, slumps, or slides. Other forms of mass movement are slow. For example, solifluction takes place discontinuously in response to near-surface processes. Solifluction is especially prevalent in the study area because the permafrost forms an impervious layer under the active layer. During the summer, the materials in the active layer thaw and become saturated because the moisture is trapped above the permafrost table. In areas of sloping terrain, these saturated materials tend to move downslope, resulting in solifluction.

The low-lying portions of the study area are expecially sensitive to surface disturbance and, when disturbed, will thaw and move downslope as landslides. This process is especially active along sea bluffs, terrace escarpments marginal to drainageways, and margins of lakes.

Poorly consolidated Tertiary shale, siltstone, and sandstone bedrock underlie, at depth, a large part of the study area, and crop out along the valleys of the Canning, Tamayariak, and Niguanak Rivers and in the area of Marsh and Carter Creeks. Locally, these deposits are susceptible to mass movements, and along the Katakturuk River and in the area of Marsh and Carter Creeks, numerous landslides have occurred.

Erosion

Erosion includes the mechanical and chemical breakdown of soil and rock and the transport of this material by running water, waves, currents, ice, or wind. Most erosion in the study area is caused by running water and takes place along all the drainageways, but it is greatest along the major rivers. Coastline erosion is also important locally because wave action, in conjunction with thawing permafrost, can cause extremely rapid retreat of coastal bluffs during major storms, especially when tides are high. Leffingwell (1919) reported shoreline recession rates of more than 30 feet per year, and Wiseman and others (1973) measured 164 feet of bluff erosion in the eastern end of Pingok Island during a 3-week period of 1972. Shorelines of the larger lakes are eroded primarily by thawing of permafrost.

Wind erosion is relatively minor except in the delta areas of the Canning, Hulahula, Okpilak, and Jago Rivers, where sand dunes are active. Easterly winds pick up material from the extensive unvegetated sand bars in the braided channels of the deltas and form cliffhead dunes along the western banks of the rivers.

BIOLOGICAL ENVIRONMENT

Terrestrial and Freshwater Environments

Vegetation and Terrain Types

The vegetation of the entire study areas lies within the tundra formation (Aleksandrova, 1970). In the tundra region, mesic (moderately wet) habitats are mostly continuously vegetated with low-growing plants, such as sedges, grasses, mosses, lichens, small herbs, and dwarf shrubs. Taller shrubs are restricted to drainages protected from winter winds and snow abrasion and to slopes with southern exposures.

Keys to the soils, landforms, vegetation, and landcover categories (table III-2) were developed from color infrared photographs (1:60,000) and from a ground-truth reconnaissance survey in 1981. A preliminary Landsat landcover map of the study area (pl. 1) and a derived simplification of this map (pl. 2) were produced in October 1981 from these field data. Planimetry data are given for the Landsat landcover categories within each terrain type and for the entire study area in appendix B, tables B-2 and B-3. The classification contains 12 landcover units:

(I)	Water
(II)	Pond Sedge Tundra Complex; Aquatic Tundra or Shallow Water
(III)	Wet Sedge Tundra
(IV)	Moist/Wet Sedge Tundra Complex; or Dry Prostrate Shrub, Forb Tundra
(V)	Moist Sedge, Prostrate Shrub Tundra; or Moist Sedge/Barren Tundra Complex
(VI)	Moist Tussock Sedge, Dwarf Shrub Tundra
(VII)	Moist Dwarf Shrub, Tussock Sedge Tundra; or Moist Sedge Tussock, Dwarf Shrub/Wet Dwarf Shrub Complex
(VIII)	Shrub Tundra
(IX)	Partially Vegetated Areas

(X) Barren Gravel or Rock
(XI) Wet Gravels, or Mud
(XII) Ice

Six regionally significant terrain types occur within the study area (fig. III-3; table III-3). Five of these are discussed in the following sections. The sixth is the 339 km^2 of ocean water that occurs within the study boundary. (See appendix B for additional photographic displays of terrain, soils, and vegetation types.)

Flat Thaw-Lake Plains

Thaw-lakes, drained lake basins, and expanses of low-centered ice-wedge polygons are found in only a few small areas of the ANWR coastal plain, primarily near the flat braided deltas of rivers (fig. III-4) and cover only 3 percent of the study area. The best developed example of thaw-lake topography occurs in the delta-confluence of the Canning and Tamayariak Rivers, an area of less than 100 square kilometers, and for some 12-15 km eastward in a narrow coastal belt; and in a narrow zone between the delta of the Hulahula River and a point some few kilometers east of the Jago River.

Except for the vegetation-covered basins of relatively recently drained lakes, some form of microrelief is nearly always present, consisting mostly of low-centered polygons, strangmoor, and featureless areas associated with pond complexes. (Note cover background photograph.)

In the thaw-lake plains, microtopography (on a scale of less than 1 m of elevation difference) plays the major influence on the distribution of plant communities. The small elevation differences create distinct patterns of plant communities and soils associations (Wiggins, 1951; Cantlon, 1961; Britton, 1957; D. A. Walker, 1981). The dominant Landsat land cover categories in the thaw-lake plains are Wet Sedge Tundra (app. B, fig. B-17), Water, Moist/Wet Sedge Tundra Complex (app. B, figs. B-18 and B-19), Aquatic Tundra (app. B, fig. B-20), and Pond Complex (background photograph on cover). The area is underlain by ice-rich permafrost at depths of about 40 cm. Except for polygon rims, the perched water table is very close to the surface or slightly above it for most or all of the thaw period.

Thaw-lake plains and coastal marshes are particularly valuable habitat for waterfowl. Spindler and Knudtson (1978) reported that flooded tundra areas are the most valuable to nesting birds on the Arctic coastal plain.

Hilly Coastal Plains

The coastal plain also contains extensive areas of gently rolling topography (fig. III-5). This type of terrain, common within the coastal plain of ANWR, covers over 22 percent of the study area. East of the Hulahula River parallel to the coast, there are numerous lightly elevated ridges and expressions, mostly with less than 30 m of relief contrast. Flat, gently sloping (5 percent or less) interfluve areas contain complexes of wet and moist tussock tundra associated with poorly developed flat-centered ice-wedge polygons. Vegetation on the ridges is mainly Moist Sedge, Prostrate Shrub Tundra and Moist Sedge/Barren Tundra Complex. (Next descriptive text begins on page IV-29.)

Table III-2.--Preliminary descriptions of vegetation and soils within the Landsat landcover categories for the Arctic National Wildlife Refuge

(In most cases colors on the Landsat image include several tundra types. The dominant types are described here, but not in order of importance)

	Color	Unit(s)	Description of vegetation and landcover units	Description of soils and landforms
I.	Dark blue	Water	Larger water bodies generally greater than 1 acre in size, ocean, lakes, and rivers.	No soil identified.
II.	Aqua	Pond Complex or Aquatic Tundra	IIa. Pond Complex.--Very wet tundra areas that have numerous small bodies of water such as in drained lake basins with small ponds, polygons, and strangmoor. Relatively well drained tundra of varying character may cover up to 50 percent of the unit. Low-centered polygon complexes with standing water in their centers are usually included in this unit.	IIa. Pond Complex.--Principal landforms of the pond complex are numerous shallow ponds less than 1 hectare, low-centered polygons, often with standing water in their centers and string bogs (strangmoor). The very wet elements of the unit have, in order of abundance, Histic Pergelic Cryaquepts usually with 20 cm or more of fibrous organic material over gleyed (reduced) mineral soil. Pergelic Cryaquepts with less than 20 cm of fibrous organic over gleyed mineral material or Cryofibrists with greater than 40 cm of fibrous organic over gleyed mineral soil. Positive microrelief elements, especially well-developed (greater than 20 cm) rims of the low-centered polygons have Pergelic Cryaquolls or occasionally Pergelic Cryaquepts with 5 to 10 cm of highly decomposed organic matter overlying gleyed mineral soil. The Pergelic Cryaquolls and, in rare circumstances, Pergelic Cryosaprists are the organically oxidized extensions of the Cryofibrists in polygon centers.
			IIb. Aquatic Tundra.--Emergent communities that cover areas greater than 1 acre. The primary taxon in deeper water, up to 1 m deep, is Arctophila fulva (Pendent Grass). In shallow water, less than 30 cm deep, the main taxa are Carex aquatilis (Aquatic Sedge), Eriophorum scheuchzeri (Arctic Cottongrass), and E. angustifolium (Common Cottongrass).	IIb. Aquatic Tundra.--Normally soils have not been described in areas where Arctophila fulva is mapped. The substrate in such environments consists commonly of a suspension of detrital organic materials often with a significant component of mineral materials held in a matrix of plant roots. Underlying mineral soils may be uniformly gleyed or on occasion show mottles, the result of oxidation around aerenchymous roots. Such soils are placed provisionally with the Pergelic Cryaquepts. Similar soils with increasing amounts of fibrous biomass occur within the shallower (less than 30 cm) water depths.

III.	Dark green	Wet Sedge Tundra	IIIa. Wet Sedge Tundra (Non-complex Type).--Relatively wet tundra with shallow or no standing water and only a few well-drained microsites associated with polygon rims, strangmoor, hummocks, etc. Much of this tundra is flooded in early summer but generally drains of standing water by mid-summer and remains saturated throughout the summer. Relatively large areas of non-complex wet tundra occur in the deltas of the large rivers, particularly the Canning River, and in drained lake basins and along some river channels. The primary taxa are numerous sedges, including Carex aquatilis (Aquatic Sedge), Eriophorum angustifolium (Common Cottongrass), E. russeolum (Russet Cottongrass), C. rotundata (Round-fruited Sedge), C. saxatilis (Rocky Sedge); a few herbs, including Pedicularis sudetica ssp. albolabiata (Sudetan Lousewort), Saxifraga hirculus (Bog Saxifrage), Melandrium apetalum (Nodding Lychnis), Caltha palustris (Marsh Marigold), and Potentilla palustris (Marsh Fivefinger). Mosses are mainly Drepanocladus spp., Scorpidium scorpioides, Campylium stellatum, Calliergon spp., and Sphagnum spp.	IIIa. Wet Sedge Tundra (Non-complex Type).--These areas have seasonal standing water (after snowmelt), but by mid-summer the thickening active layer together with evapotranspiration removes the standing water leaving a saturated soil; free water is encountered within a very few centimeters of the surface. Patterned ground features are poorly developed and consist of large disjunct polygons, hummocks, and strangmoor; the strangs are often coextensive with the low rims of polygons. All in all, there is not much positive microrelief. The soils, like the surface, are wet, predominantly Pergelic Cryaquepts or Histic Pergelic Cryaquepts, both of which have fibrous organic horizons. In certain cases where organic and neutral- to alkaline-mineral substrate is present, Histic Pergelic Cryaquolls occur.
			IIIb. Wet Sedge Tundra (Very Wet Complexes).--Complexes of wet tundra with up to 50 percent water or emergent vegetation. Low-centered polygon complexes, areas with extensive thermokarst pits, or complex thermokarst areas in the foothills are common areas with this vegetation subunit. Non-aquatic portions of the complex may be tundra of varying character including Moist Non-tussock Tundra (Va), Moist Tussock Sedge, Dwarf Shrub Tundra (VI), Dry Sedge, Crustose Lichen Tundra (Va), and Wet Saline Tundra (IIId).	IIIb. Wet Sedge Tundra (Very Wet Complexes).--In contrast to IIIa, these are areas with more strongly expressed surface patterns and microrelief and with significant amounts of standing water in the form of thermokarst pools or in the centers of low-centered polygons. Such areas are typical of broad crests in the foothills regions and portions of the rolling coastal plain. Moist tussock and tussock frost-scar slopes in this subregion have Pergelic Cryaquolls and/or Ruptic-Entic Cryaquolls. Pergelic Cryaquolls commonly form associations with Pergelic and Histic Pergelic Cryaquepts where low-centered polygons are well expressed. Complexes of Pergelic Cryaquolls and Pergelic and Histic Pergelic Cryaquepts characterize the unit generally.

Table III-2.--Preliminary descriptions of vegetation and soils within the Landsat landcover categories for the Arctic National Wildlife Refuge--Con.

	Color	Unit(s)	Description of vegetation and landcover units	Description of soils and landforms
III.	Dark green	Wet Sedge Tundra	IIIc. Wet Sedge Tundra (Moist Complexes).--Complexes of wet tundra with up to 40 percent moist tundra of varying character. Low-centered polygon complexes with well-developed polygon rims, and string-bogs with closely spaced strangs are common areas with this vegetation subunit.	IIIc. Wet Sedge Tundra (Moist Complexes).--This subunit differs from the others principally in terms of being better drained. There are more extensive areas of well-developed low-centered polygons and areas of string bogs in which the strings are more closely spaced, reflecting a more clearly defined hydraulic gradient. Pergelic and Histic Pergelic Cryaquepts are common to the rest of the subunit.
			IIId. Wet Sedge Tundra (Saline Facies).--Areas near the coast that are periodically inundated with salt water. The primary taxa are Carex subspathacea, (Hoppner Sedge), Puccinellia phryganodes (Creeping Alkali-grass), C. ursina (Bear Sedge), Stèllaria humifusa (Low Chickweed), and Cochlearia officinalis (Common Scurvy Grass). Some saline areas have numerous ponds and are likely to be classed as Pond Complex (II).	IIId. Wet Sedge (Saline Facies).--These near-coast areas may display any of the landform subunits of categories II or III except IIIb. The soils in recently flooded areas are morphologically little different from those of the unflooded parts. Chemically, however, they may have conductivities that range from 12,000 to greater than 18,000 umhos/cm and should probably be considered as Halic Pergelic Cryaquepts (proposed by S. Rieger, in press) and, in some cases, Halic Histic Pergelic Cryaquepts. Where saline conditions have prevailed for a protracted period of time and salt-tolerant plants, such as Puccenellia phryganodes and Carex subspathacea, are established on the dead Carex aquatilis there is a pronounced change in the texture of the accumulating organic matter
IV.	Light green	Moist/Wet Sedge Tundra Complex or Dry Prostrate Shrub, Forb Tundra (problem category)	IVa. Moist/Wet Sedge Tundra Complex.--Areas of moist sedge tundra mixed with up to 40 percent wet sedge tundra. Flat areas with low- or flat-centered polygon complexes (common in drained lake basins) or strangmoor (more common in river delta systems and on gentle slopes) usually have a large percentage cover of wet tundra in the polygon troughs, basins, thermokarst pits and inter-strang areas. The spectral signature of these areas are likely to vary depending on the season and the summer rainfall. Moist areas may or may not have cottongrass tussocks, depending on proximity to the coast. Common taxa in moist tundra areas include the sedges Eriophorum triste (Common Cottongrass), E. vaginatum (Sheathed Cottongrass),	IVa. Moist/Wet Sedge Tundra Complex.--Occurs on flat upland areas or in old drained lake basins where flat-centered polygons form complexes with thermokarst pits or with strangmoor. Wet areas may comprise up to 40 percent of any given area. The moist/wet sedge tundra is also common to gentle slopes with flat-centered polygons. The IVa subunit is most extensive east of the Hulahula River. Soils of the moist areas (polygon centers especially) are Pergelic Cryaquolls. Those of the wet sites are Histic Pergelic Cryaquolls or Histic Pergelic Cryaquepts. In areas where frost scars are common to the moist sites, the soil complex is best described as one of Ruptic-Entic Pergelic Cryaquolls.

IV.	Light green	Moist/Wet Sedge Tundra Complex or Dry Prostrate Shrub, Forb Tundra (problem category)	Carex bigelowii (Bigelow's Sedge), C. membranacea (Fragile Sedge); the prostrate shrubs Dryas integrifolia (Arctic Avens), Salix reticulata (Net-veined willow), S. arctica (Arctic Willow), S. pulchra (Diamond-leafed Willow), S. lanata (Woolly Willow); and the forbs Pedicularis lanata (Woolly Lousewort), Polygonum bistorta (Bistort), Stellaria laeta (Long-stalked Stitchwort), and Senecio atropurpureus ssp. frigidus (Arctic Senecio). Common bryophytes include Tomenthypnum nitens, Hylocomium splendens, Ptilidium ciliare, Orthothecium chryseum, and Ditrichum flexicaule. Common lichens are Thamnolia subuliformis, Cetraria ssp., Dactylina arctica, Cladonia spp., and Cladina spp.

IVb. Dry Prostrate Shrub, Forb Tundra (Dryas River Terraces).--River terraces with a dense prostrate mat of Dryas integrifolia and numerous small forbs and prostrate shrubs. This unit is quite dark on aerial photography and Landsat data and has a spectral signature similar to either Wet Sedge Tundra (III) or Moist/Wet Sedge Tundra Complex (IVa), although this unit is physiognomically very different from either of these other units. This is a common unit along rivers, particularly along the Canning River, and used heavily by ground squirrels, lemmings, and bears. It may be possible to distinguish these terraces in some other phenological stage on Landsat scenes taken later in the summer. The primary taxa are the prostrate shrubs Dryas integrifolia (Arctic Avens), Salix reticulata (Net-veined Willow), S. rotundifolia (Round-leafed Willow), and S. ovalifolia (Oval-leafed Willow); the herbs Astragalua alpinus (Alpine Milk-vetch), Oxytropis nigrescens (Blackish Oxytrope), Equisetum arvense (Common Horsetail), Artemisia

IVb. Dry Prostrate Shrub, Forb Tundra (Dryas River Terraces).--These terraces are generally components of the riverine complex. Except under unusual circumstances they are not flooded, being a meter or more above the active terraces or river island complex. Surfaces of these terraces still display the river island and channel features. The river island component commonly displays polygonal cracks and has soils resembling Cryofluvents with 15 to 50 cm of interlayered silts, sands, and organic materials overlying riverwash sands and gravels. Permafrost is greater than 1 m and no water table occurs. Former channels are wet to moist and have Pergelic Cryaquept soils.

Table III-2.--Preliminary descriptions of vegetation and soils within the Landsat landcover categories for the Arctic National Wildlife Refuge--Con.

	Color	Unit(s)	Description of vegetation and landcover units	Description of soils and landforms
IV.	Light green	Moist/Wet Sedge Tundra Complex or Dry Prostrate Shrub, Forb Tundra (problem category)	arctica (Arctic Wormwood), Silene acaulis (Moss Campion), Chrysanthemum integrifolium (Entire-leafed Chrysanthemum), Saxifraga oppositifolia (Purple Mountain Saxifrage), Carex membranacea (Fragile Sedge), and Eriophorum triste (Common Cottongrass); and the mosses Distichium capillaceum and Ditrichum flexicaule.	
V.	Sand	Moist Sedge, Prostrate Shrub Tundra or Moist Sedge/ Barren Tundra Complex (problem category)	Va. Moist Sedge, Prostrate Shrub Tundra.--Moderately well drained areas, located primarily along the northern part of the foothills and in drainages. Principal taxa are similar to those described for Moist/Wet Sedge Tundra Complex (IVa). These areas may have up to 20 percent cover of cottongrass tussocks. Wetter facies near streams are likely to have no tussocks and to have high percentages of prostrate shrubs, including Salix arctica (Arctic Willow) and S. pulchra (Diamond-leafed Willow), and herbs such as Petasites frigidus (Lapland Butterbur), Saxifraga punctata (Cordate-leafed Saxifrage), Carex aquatilis (Water Sedge), Saxifraga hirculus (Bog Saxifrage), and Valariana capitata (Capitate Valerian). Near the coast, on slightly elevated microsites, moist tundra areas are likely to contain large components of a prostrate shrub, crustose lichen type. This type is a rather sparse community including Dryas integrifolia (Arctic Avens), Salix pulchra (Diamond-leafed Saxifrage), Carex bigelowii (Bigelow's Sedge), S. phlebophylla (Veiny-leafed Willow), Luzula arctica (Arctic Wood-rush); with considerable groundcover of small hummocks with the moss Dicranum elongatum covered by white crustose lichens (mainly Ochrolechia frigida and Lecanora epibryon). Vb. Moist Sedge/Barren Tundra Complex (Frost-scar Tundra).--Well-drained areas with as much as 90 percent of the surface covered by frost-boils or frost-rings. Vegetation on the frost scars is generally sparse with such taxa as Juncus biglumis	V. Moist Sedge, Prostrate Shrub Tundra or Moist Sedge/Barren Tundra Complex.--This cover category is mostly in the northern or rolling foothills of the wildlife refuge and is commonly difficult to separate from landcover unit IVa in that it occupies broad sloping interfluves with flat-centered polygons. The soils are Pergelic Cryaquolls with a small percentage of Pergelic Cryaquepts. Portions of the slopes have a very high percentage of frost scars--in some cases 75 percent or more. These areas are especially common on crests with bedrock at or close to the surface and areas low on the slopes near drainages. Soils of the frost scars are Pergelic Cryaquepts; more stable areas between the frost scars (10 to 50 percent of the surface) are Pergelic Cryaquolls. Active layer thickness ranges from near a meter in the scars to between 40 and 60 cm beneath the Pergelic Cryaquolls. Portions of the long, low slopes are characterized by tussock-water track tundra (landcover unit VIIc).

V.	Sand	Moist Sedge, Prostrate Shrub Tundra or Moist Sedge/ Barren Tundra Complex (problem category)	(Two-flowered Rush), Arctagrostis latifolia (Wide-leafed Arctagrostis), Petasites frigidus (Lapland Butterbur), Dryas integrifolia (Arctic Avens), Chrysanthemum integrifolium (Entire-leafed Chrysanthemum) and Saxifraga opositifolia (Purple Mountain Saxifrage, and the mosses Rhacomitrium lanuginosum, Bryum spp., Distichium capillaceum, Drepanocladus uncinatus, etc. Inter-frost-scar areas near the coast are usually Moist Sedge Tundra (Va) dominated by Carex bigelowii (Bigelow's Sedge), Dryas integrifolia (Arctic Avens), Arctagrostis latifolia (Wide-leafed Arctagrostis), Equisetum arvense (Common Horsetail), and the moss Tomenthypnum nitens. In the foothills frost-scar tundra occurs mainly on slopes and ridge tops and is likely to have scattered dwarf shrubs (10 to 40 cm tall) of Salix lanata (Woolly Willow) or S. glauca (Northern Willow). This unit is extensive but is difficult to separate on the Landsat data. On the Flaxman scene, it is most often classified as Unit V (sand), whereas on the Canadian scene, it often appears as Unit IV (light green).	
VI.	Light brown	Moist Tussock Sedge, Dwarf Shrub Tundra	VIa. Moist Tussock Sedge, Dwarf Shrub Tundra (Upland Tussock Tundra, Acidic Facies).-- Relatively well drained upland tussock tundra sites primarily in the foothills with high percentage cover of cottongrass tussocks and dwarf or prostrate shrubs. Tussocks are usually dominant with about 20 to 70 percent cover. On acidic soils the dwarf shrubs include Salix pulchra (Diamond-leafed Willow), Betula nana (Dwarf Birch), Ledum decumbens (Narrow-leafed Labrador Tea), Vaccinium uliginosum (Bog Blueberry), V. vitis-idaea (Mountain Cranberry, Empetrum nigrum (Crowberry), Arctostaphylos rubra (Bearberry), and Cassiope tetragona (Four-angled Mountain Heather); and the bryophytes are mainly Hylocomium splendens, Sphagnum spp., Aulacomnium palustre, and Ptilidium ciliare. Lichens are dominated by Cladonias and Cladinas.	VI. Moist Tussock Sedge, Dwarf Shrub Tundra.-- Two facies, acid and alkaline, are recognized in this foothills unit. Landforms are principally long slopes dominated by cottongrass tussocks that obscure flat-centered polygons. The acidic facies of the unit occur in association with sand and gravel conglomerate units of the underlying Cretaceous and/or Tertiary bedrock and are particularly common in the area west of the Katakturuk River. The soils are Pergelic Cryaquepts and form a complex with numerous frost scars (Ruptic-Entic Pergelic Cryaquepts). Histic Pergelic Cryaquepts are common where water track units occur. Alkaline facies of this cover category are most common east of the Katakturuk River and the soil complex is Ruptic-Entic Pergelic Cryaquolls. Water tables are generally absent in the moist portions of both

Table III-2.--Preliminary descriptions of vegetation and soils within the Landsat landcover categories for the Arctic National Wildlife Refuge--Con.

	Color	Unit(s)	Description of vegetation and landcover units	Description of soils and landforms
VI.	Light brown	Moist Tussock Sedge, Dwarf Shrub Tundra	VIb. Moist Tussock Sedge, Dwarf Shrub Tundra (Alkaline Facies).--Tussock tundra on more neutral or basic soils. Important taxa include Dryas integrifolia (Arctic Avens), Carex bigelowii (Bigelow's Sedge), Salix arctica (Arctic Willow), S. reticulata (Net-leafed Willow), S. lanata (Woolly Willow); the chief moss is Tomenthypnum nitens; and lichens are mainly Cetrarias. The alkaline soils are most often a result of frost-stirring of basic parent materials, and barren frost-scars can cover a large percentage of this unit. Both VIa and VIb may have up to 30 percent coverage of other vegetation types, mainly Moist Sedge - Prostrate Shrub Tundra (IVa) or Wet Sedge Tundra (III).	facies except in water tracks and near the foot and crest of the slope. Pergelic Cryochrepts are present on the few well-drained areas within this category.
VII.	Dark brown	Moist Dwarf Shrub, Tussock Sedge Tundra or Moist Tussock Sedge, Dwarf Shrub/Wet Dwarf Shrub Tundra Complex	VIIa. Moist Dwarf Shrub, Tussock Sedge Tundra (Upland Dwarf Shrub Tussock Tundra).--Upland tundra similar to Unit VI except here shrubs, mainly Salix pulchra (Diamond-leafed Willow) and Betula nana (Dwarf Birch), are dominant and may reach heights of up to 50 cm.	VIIa. Moist Dwarf Shrub, Tussock Sedge Tundra.--This unit is generally similar to land cover category VI in terms of soils.
			VIIb. Moist Dwarf Shrub, Tussock Sedge Tundra (Birch Tundra).--High-centered polygons and palsas with dwarf shrub communities dominated by Betula nana (Dwarf Birch) and Eriophorum vaginatum (Sheathed Cottongrass). These areas occur on high-centered polygons toward the southern end of the coastal plain and in low thermokarst drainage areas in the foothills. In some communities the birch is completely dominant and the cottongrass is absent. Other typical taxa in these sites are Rubus chamaemorus (Cloudberry), Ledum decumbens (Narrow-leafed Labrador Tea), Pedicularis labradorica (Labrador Lousewort), Vaccinium vitis-idaea (Mountain Cranberry); the mosses Sphagnum spp. dominate the ground layer with numerous Cladonia and Cladina lichens.	VIIb. Moist Dwarf Shrub, Tussock Sedge Tundra (Birch Tundra).--This unit occurs principally in the headwater areas of many small, often beaded drainages in the foothills area. In such areas thermal erosion combines with natural thermokarst to produce, by way of topographic reversal, high-centered polygons which may have a meter or more microrelief. Soils, which in uneroded portions of the headwater basins are Histic Pergelic Cryaquepts or Pergelic Cryohemists, are converted to (Sapric) Histic Pergelic Cryaquolls or Pergelic Cryosaprists by virtue of the better drainage afforded by the microrelief difference. A feature of headwater basins and some broad interfluves (unit IIIb) especially in the southern part of the foothills area are birch-covered peat plateaus

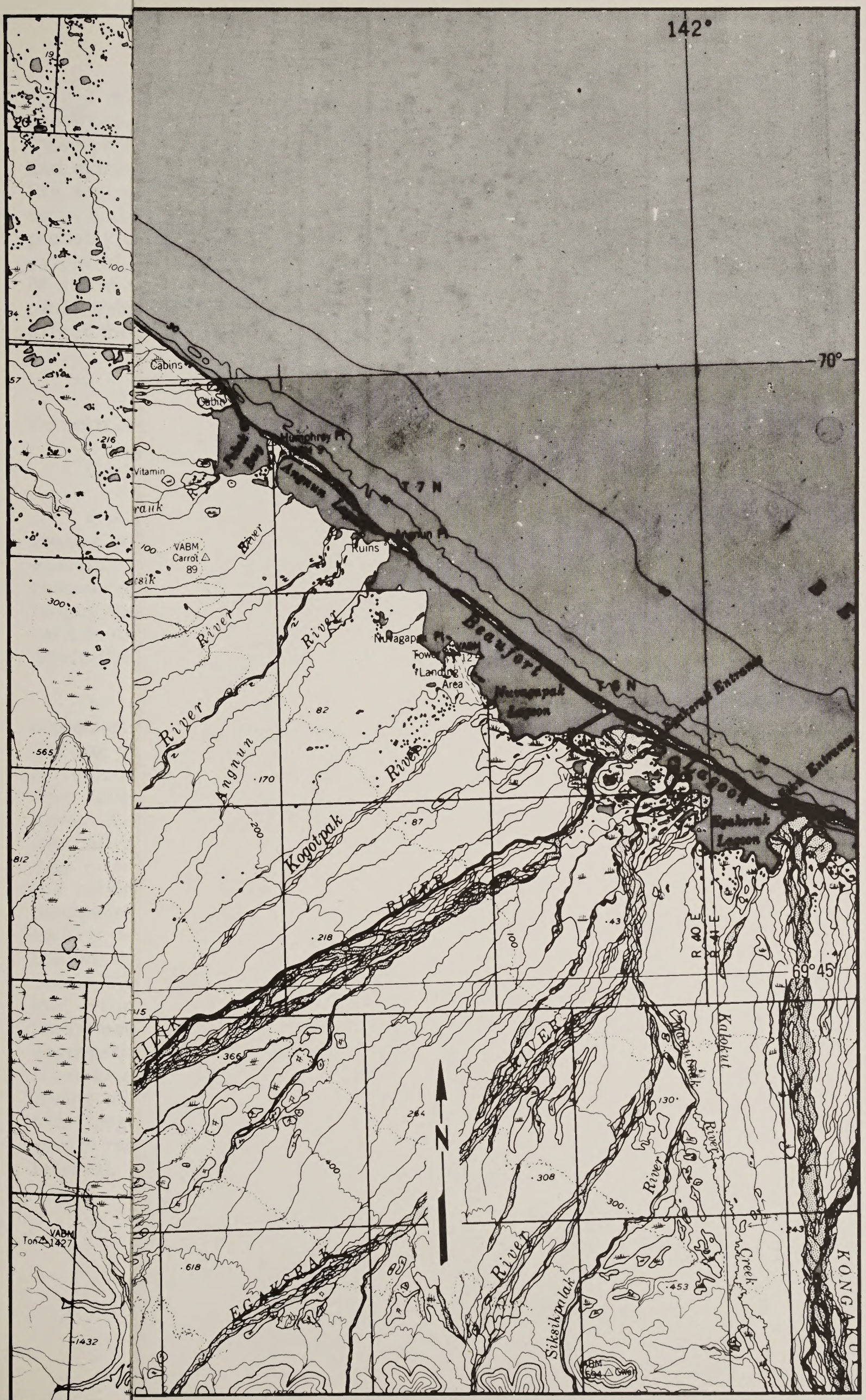
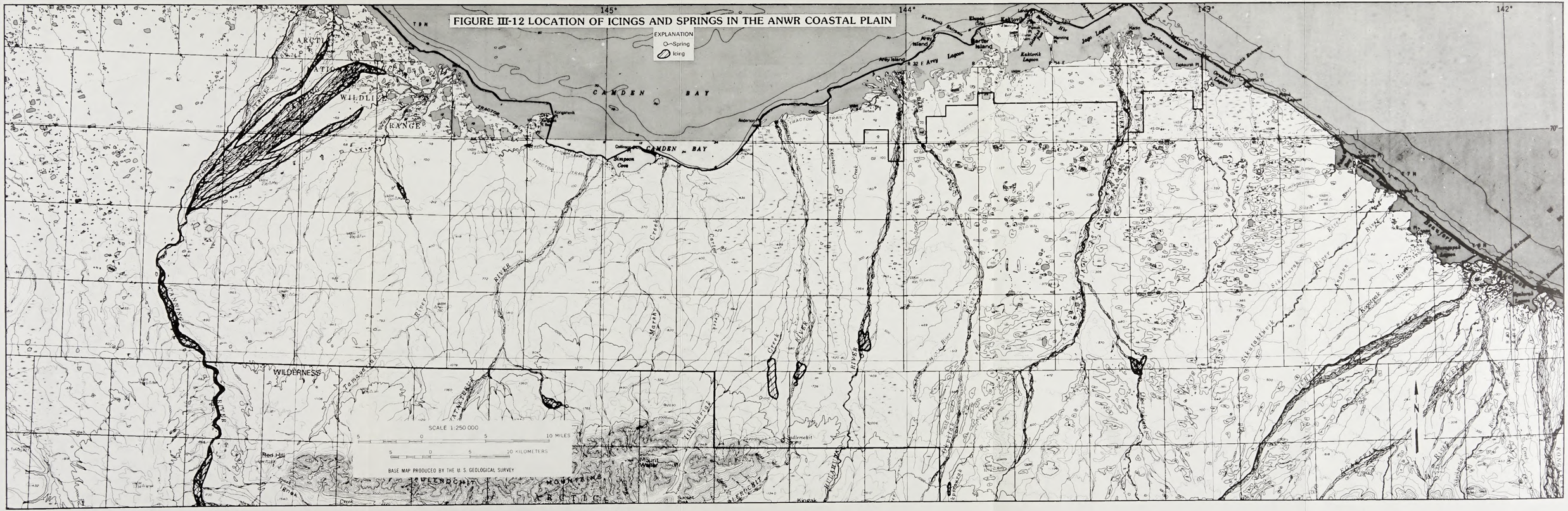

142°
70°
69° 45'
Cabins
Cabin
Humphrey Pt
Vitamin
VABM
Carrot △
89
Ruins
River
Nuvagapak Pt
Tower
Landing
Area
Beaufort
Nuvagapak
Lagoon
Angnu
Kogotpak
BLUFF
Kaktovik
Kaktovik Creek
Siksikpilak
KONGAKUT
Kongakut
Creek
R 40 E
R 41 E
VABM
Ton △
1427
VABM
554 △
Cairn

Table III-2.--Preliminary descriptions of vegetation and soils within the Landsat landcover categories for the Arctic National Wildlife Refuge--Con.

	Color	Unit(s)	Description of vegetation and landcover units	Description of soils and landforms
VI.	Light brown	Moist Tussock Sedge, Dwarf Shrub Tundra	VIb. Moist Tussock Sedge, Dwarf Shrub Tundra (Alkaline Facies).--Tussock tundra on more neutral or basic soils. Important taxa include Dryas integrifolia (Arctic Avens), Carex bigelowii (Bigelow's Sedge), Salix arctica (Arctic Willow), S. reticulata (Net-leafed Willow), S. lanata (Woolly Willow); the chief moss is Tomenthypnum nitens; and lichens are mainly Cetrarias. The alkaline soils are most often a result of frost-stirring of basic parent materials, and barren frost-scars can cover a large percentage of this unit. Both VIa and VIb may have up to 30 percent coverage of other vegetation types, mainly Moist Sedge - Prostrate Shrub Tundra (IVa) or Wet Sedge Tundra (III).	facies except in water tracks and near the foot and crest of the slope. Pergelic Cryochrepts are present on the few well-drained areas within this category.
VII.	Dark brown	Moist Dwarf Shrub, Tussock Sedge Tundra or Moist Tussock Sedge, Dwarf Shrub/Wet Dwarf Shrub Tundra Complex	VIIa. Moist Dwarf Shrub, Tussock Sedge Tundra (Upland Dwarf Shrub Tussock Tundra).--Upland tundra similar to Unit VI except here shrubs, mainly Salix pulchra (Diamond-leafed Willow) and Betula nana (Dwarf Birch), are dominant and may reach heights of up to 50 cm.	VIIa. Moist Dwarf Shrub, Tussock Sedge Tundra.--This unit is generally similar to land cover category VI in terms of soils.
			VIIb. Moist Dwarf Shrub, Tussock Sedge Tundra (Birch Tundra).--High-centered polygons and palsas with dwarf shrub communities dominated by Betula nana (Dwarf Birch) and Eriophorum vaginatum (Sheathed Cottongrass). These areas occur on high-centered polygons toward the southern end of the coastal plain and in low thermokarst drainage areas in the foothills. In some communities the birch is completely dominant and the cottongrass is absent. Other typical taxa in these sites are Rubus chamaemorus (Cloudberry), Ledum decumbens (Narrow-leafed Labrador Tea), Pedicularis labradorica (Labrador Lousewort), Vaccinium vitis-idaea (Mountain Cranberry); the mosses Sphagnum spp. dominate the ground layer with numerous Cladonia and Cladina lichens.	VIIb. Moist Dwarf Shrub, Tussock Sedge Tundra (Birch Tundra).--This unit occurs principally in the headwater areas of many small, often beaded drainages in the foothills area. In such areas thermal erosion combines with natural thermokarst to produce, by way of topographic reversal, high-centered polygons which may have a meter or more microrelief. Soils, which in uneroded portions of the headwater basins are Histic Pergelic Cryaquepts or Pergelic Cryohemists, are converted to (Sapric) Histic Pergelic Cryaquolls or Pergelic Cryosaprists by virtue of the better drainage afforded by the microrelief difference. A feature of headwater basins and some broad interfluves (unit IIIb) especially in the southern part of the foothills area are birch-covered peat plateaus

FIGURE III-12 LOCATION OF ICINGS AND SPRINGS IN THE ANWR COASTAL PLAIN


145°
144°
143°
142°
70°
EXPLANATION
Spring
Icing
CAMDEN BAY
WILDERNESS
RANGE
SCALE 1:250 000
5 0 5 10 MILES
5 0 5 10 KILOMETERS
BASE MAP PRODUCED BY THE U. S. GEOLOGICAL SURVEY
Barter Island
Kaktovik Lagoon
Simpson Cove
Sadlerochit Spring
Mount Wiley
Red Hill
Jago Lagoon
Tapkaurak Lagoon
Okpilak River
Hulahula River
Aichilik River
Niguanak Lagoon
Angun Lagoon
Kongakut River
Marsh Creek
Tamayariak River
Sikuliaroak River
Angun River
Okerokovik Creek
Nanushuk River
Tapkaurak Pt.
Arey Island
Arey Island Lagoon
Kaktovik
Kongakut
Anderson
Okerokovik
Simpson Cove
Camden Bay
Tapkaurak Lagoon
Niguanak Lagoon
Angun Lagoon
Jago Lagoon
Kaktovik Lagoon
Barter Island
Arey Island
Arey Island Lagoon
Kongakut River
Marsh Creek
Okpilak River
Hulahula River
Aichilik River
Nanushuk River
Tamayariak River
Sikuliaroak River
Angun River
Okerokovik Creek
Tapkaurak Pt.
Kaktovik
Kongakut
Anderson
Okerokovik
Simpson Cove
Camden Bay
Sadlerochit Spring
Mount Wiley
Red Hill
Jago Lagoon
Tapkaurak Lagoon
Niguanak Lagoon
Angun

Coastal/Marine Environment

The coastal/marine habitats fronting the study area include those offshore, nearshore, open coast, deltas, and barrier islands-lagoons-mainland shore areas, and those portions of the coastal uplands, that are directly affected by storm surges and marine saline intrusions. These areas provide essential shelter, staging, and life support to the resident and migratory fish and wildlife population. Beaches, spits, and bars occupy a very small part of the study area. Permafrost, although it probably underlies these sites, does not enter into the soil taxonomy. The inland extent of the coastal/marine environment is defined by the maximum inland reach of storm surges, and is identified in many areas by the "strand line" of logs and other debris, and by the extent to which salt spray and ingress of saline water affect the vegetative cover along the coast.

Fish and Wildlife Resources

Terrestrial Mammals

Caribou (Rangifer tarandus granti)

Caribou are highly gregarious members of the deer family (Cervidae) which usually occur in distinct populations or "herds" (fig. III-13). Most caribou herds undertake annual migrations which follow fairly predictable routes, although considerable variation can occur in some years. Large herds tend to occupy larger ranges and migrate longer distances than smaller herds. The central focal point of caribou migrations during spring is the calving grounds, which are traditional areas where the young are born.

In Arctic areas, caribou populations are highly synchronous in their reproductive cycles. A single calf is born annually to most adult females in a herd. Calving occurs usually within a period of 2 to 3 weeks at the end of May and in early June. Caribou calves are precocious, being able to stand and nurse within 1 hour following birth. They are capable of travel with adults within less than a week. A critical time is during the first 24 hours, when a bond is formed between the calf and its mother. Disturbance of maternal groups on the calving grounds may interfere with bond formation and greatly influence calf mortality. During the calving and postcalving period (May-August), females and females with young demonstrate a high degree of sensitivity to human disturbances. Soon after the calving period, herds often form into large dense groups (aggregations) which often involve major portions of the population. The postcalving season is a time of low ebb in the annual physiological cycle and the energy reserves of parturient cows is low. The stresses of winter, pregnancy, migration, birth, lactation, and insect harassment draw heavily upon this segment of the population. Postcalving aggregations tend to stampede easily, sometimes resulting in cow-calf separations, trampling, and increased calf mortality. Insect harassment is often quite severe during mid- to late summer. Later in summer (August) caribou tend to disperse over large areas. In the fall, groups of caribou begin to gradually move toward winter ranges. Breeding occurs during the autumn migrations in a fairly brief time interval.

Figure III-13.--A small number of the Porcupine Caribou Herd grazing along the foothills.

LEGEND

L LIMIT - PORCUPINE CARIBOU HERD (1972-1980)

IPAL CALVING AREA - PORCUPINE CARIBOU HERD

RY WINTER RANGES - PORCUPINE CARIBOU HERD

LIMIT - CENTRAL ARCTIC CARIBOU HERD (CAH)

IPAL CALVING AREA - CAH

R RANGE ONLY - CAH

N

0 50 MILES

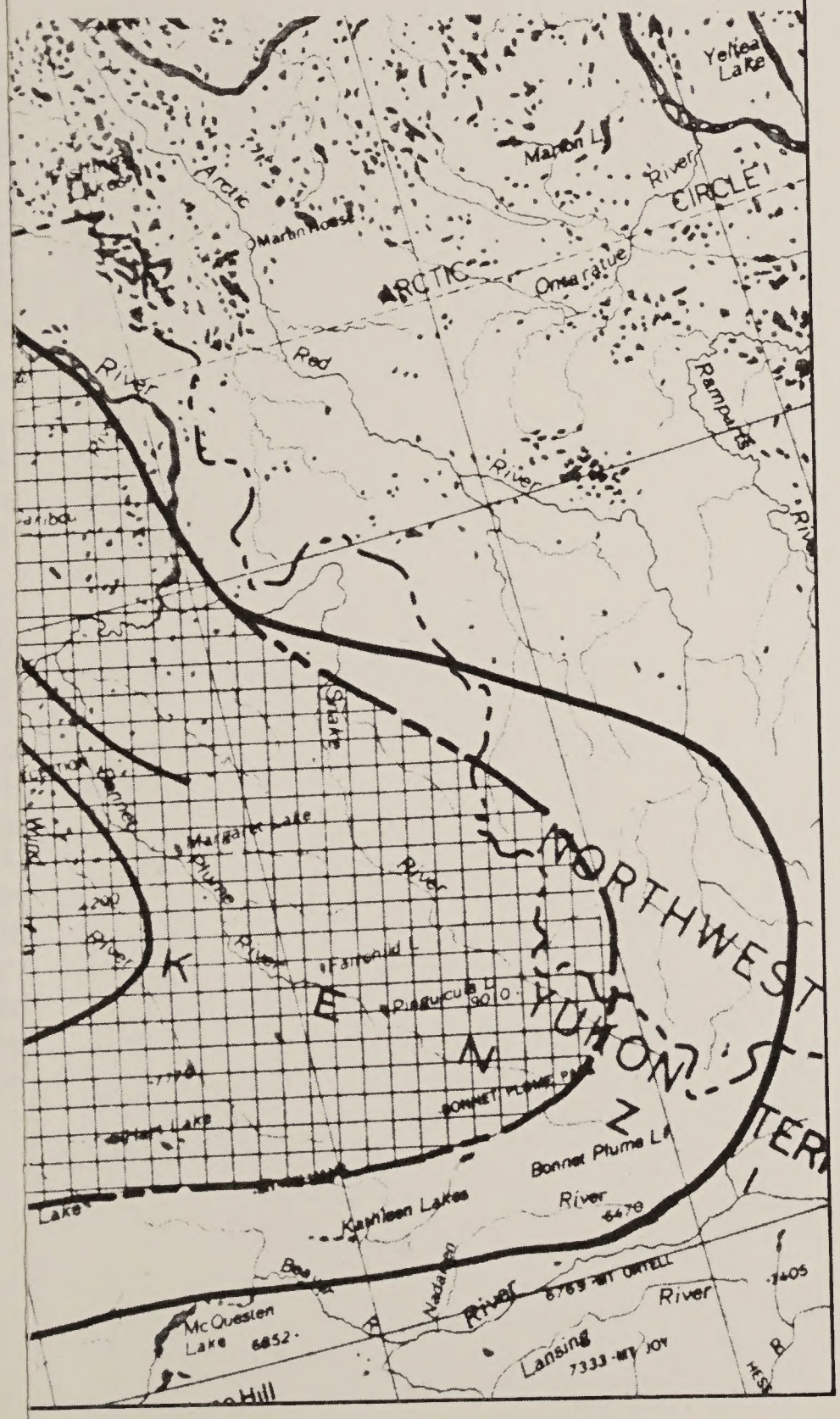


Figure III-13.--A small number of the Porcupine Caribou Herd grazing along the foothills.

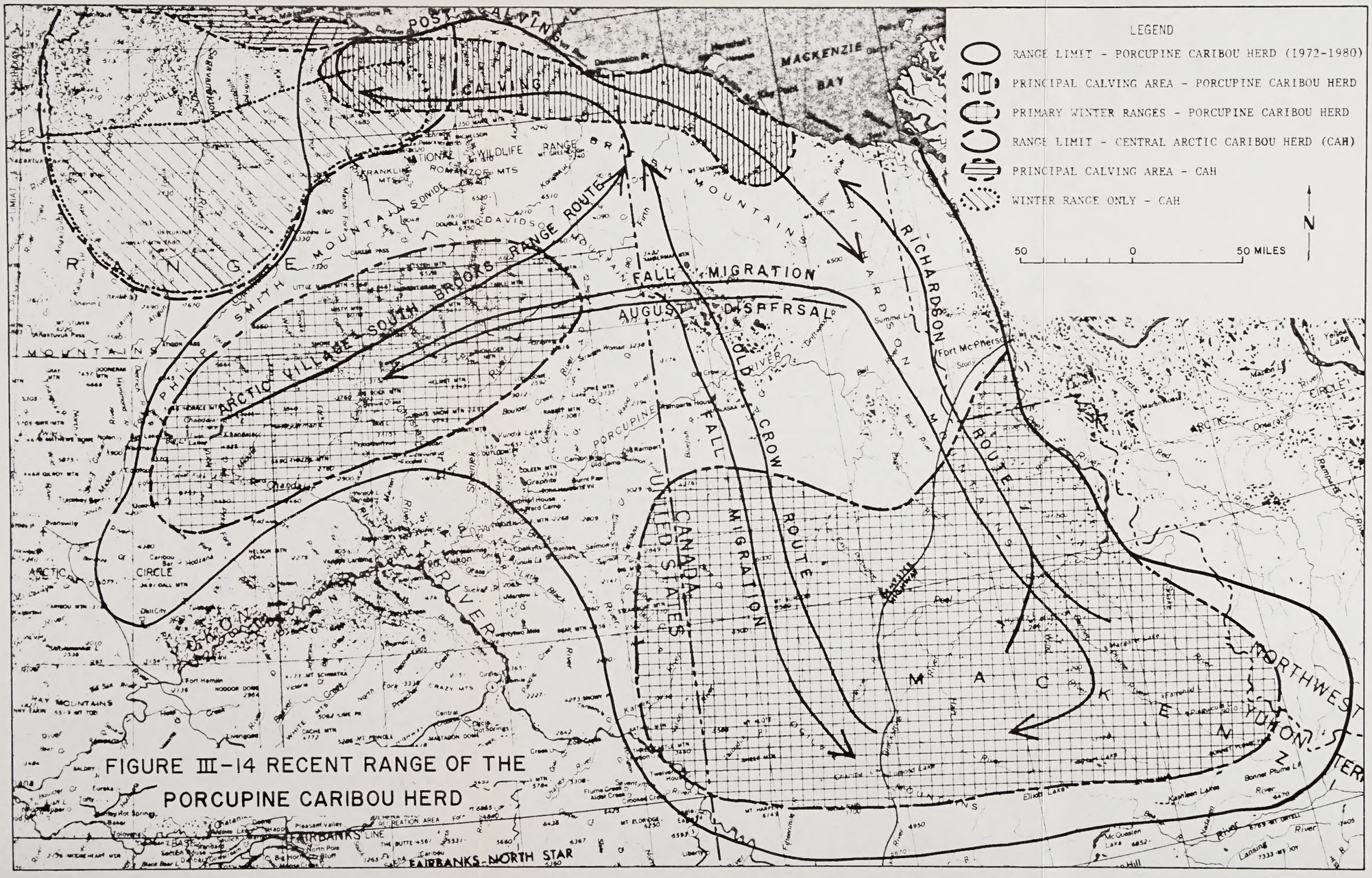


FIGURE III-14 RECENT RANGE OF THE PORCUPINE CARIBOU HERD

Snow conditions and forage resources seem to influence the distribution of wintering caribou. Most northern caribou populations rely heavily on lichens for sustenance during winter, although a variety of sedges and shrubs are also consumed. During spring and summer, caribou feed on many plant resources such as sedges, certain floral parts of plants, willow shoots and lichens.

Two caribou herds, the Porcupine and Central Arctic, are associated with the ANWR study area (fig. III-14). The Porcupine Herd (estimated at 110,000 animals in 1979) is one of the largest caribou herds in North America. It ranges over approximately 250,000 square kilometers in northeasten Alaska and northwestern Canada. In recent winters, the Porcupine Herd has wintered in both the central Yukon Territory and in the vicinity of Arctic Village, Alaska. Spring migrations usually begin in early April. The arrival date of pregnant cows on the traditional calving grounds seems to be dependent on snow conditions and the location of wintering areas. The Porcupine Herd's calving grounds are international, extending along the Arctic foothills and coastal plain from the Babbage River in the Yukon Territory to the Canning River in Alaska.

Caribou of the Porcupine herd usually enter calving grounds within the ANWR study area during mid- to late May. The first calves are born during the last week of May, with the peak of calving occurring between June 5 and 9. Although calving has been observed in a variety of terrains, most calves are born in snow-free areas of tussock (Eriophorum) uplands. Major calving concentrations of the Porcupine Herd have occurred in the study area between Camden Bay and the Sadlerochit Mountains (from the Canning River in the west to the Sadlerochit River). Concentrations of calving activity also occur within the ANWR study area along the foothills from Sadlerochit River to the Aichilik River. Scattered calving activity has been reported throughout the study area.

Following calving, maternal groups of the Porcupine Herd usually move northward and westward, gradually coalescing into aggregations. By late June it is common to find huge aggregations (80,000 or more animals) in the study area between Camden Bay and the Sadlerochit Mountains. In early July these great herds move east, usually reaching the Canadian border by mid-July.

The Central Arctic Caribou Herd currently numbers abut 7,000-9,000 and has recently been increasing. It occupies a range which is entirely north of the Brooks Range continental divide, from the Itkillik and Colville Rivers on the west to slightly east of the Canning River. The Trans-Alaska Pipeline (TAPS)-Dalton Highway corridor and Prudhoe Bay-Kuparuk oilfields lie within the herd's range. Calving activity of the Central Arctic Herd recently has been concentrated in two areas: the vicinity of the lower Kuparuk River and on the Canning River Delta of the ANWR study area. Little or no calving activity has been observed in the TAPS-Prudhoe Bay oilfield area since about 1973. Caribou of the Central Arctic Herd use the ANWR study area (Canning River Delta and coastal habitats along Camden Bay) for postcalving activities and insect relief. Residents of Kaktovik harvest Central Arctic Herd caribou from coastal areas during the summer. During some winters, scattered groups of caribou, believed to be of the Central Arctic Herd, range through the ANWR study area and adjacent uplands to the south.

Muskoxen (Ovibus moschotus)

Man eliminated muskoxen from the North Slope before 1900 and then reintroduced them to the Arctic coastal plain within the study area in 1969-70. Three general areas of muskoxen distribution occur within the study area. The total refuge population is estimated at approximately 200 animals; it has more than doubled since 1978 (Baseline Study, U.S. Fish and Wildlife Service, 1982). Figure III-15 presents information on their distributions since 1974.

Muskoxen are not migratory; movements are restricted, typically ranging from less than 1 to several kilometers per day. They normally have a strong fidelity for a limited home range area, often seldom more than 100 square kilometers in extent. Muskoxen are not normally attacked by parasitic flies as caribou are; thus, they are not subject to the stress which significantly decreases the time spent feeding and increases the movement rate. Winter distribution is primarily controlled by distribution of favored forage species and snow cover conditions. Deep snow hampers movement and foraging, and muskoxen tend to avoid areas having greater than 30 cm of snow. There are no indications of territoriality during any season, but there are well-defined herd home ranges (U.S. Fish and Wildlife Service, 1982; Lent, 1978).

Muskoxen are generally gregarious; the size of groups tends to decrease in the summer prior to rutting activities. When confronted by predators and other direct threats, muskoxen often bunch and assume circular or compact defensive formations.

Muskoxen prefer riparian habitats. Willows are preferred, where they exist (see fig. B-28), although sedges and forbs make up a high proportion of the total food intake. Because the preferred food species are primarily associated with riparian habitats, the present distribution of most muskoxen is restricted to major drainages of the study area during all seasons (Lent, 1978).

Moose (Alces alces gigas)

Distributional patterns of moose north of the Brooks Range vary seasonally, with animals being concentrated in the major river valleys in the mountains during the winter and throughout the foothills, mountains, and coastal plain during the summer months (Baseline Study, U.S. Fish and Wildlife Service, 1982). In April and early May, moose move northward along riparian systems and tend to aggregate in small widely dispersed groups. The extent of the use of the coastal plain by moose and its importance to the overall moose populations inhabiting the adjacent river drainages of the Brooks Range is presently unknown.

Moose are generally solitary, but tend to aggregate in response to such factors as severe weather, mating, or limited habitat. Males exhibit aggressive, structured behavior during the rut. Cows are also aggressive toward one another during the breeding season.

Calving occurs in late May or early June, after which a significant but unknown proportion of the animals disperse onto the coastal plain for the summer.

EFUGE 1974 TO 1981

Scale 1:500,000

6 0 6 12 18 Miles

N

LEGEND

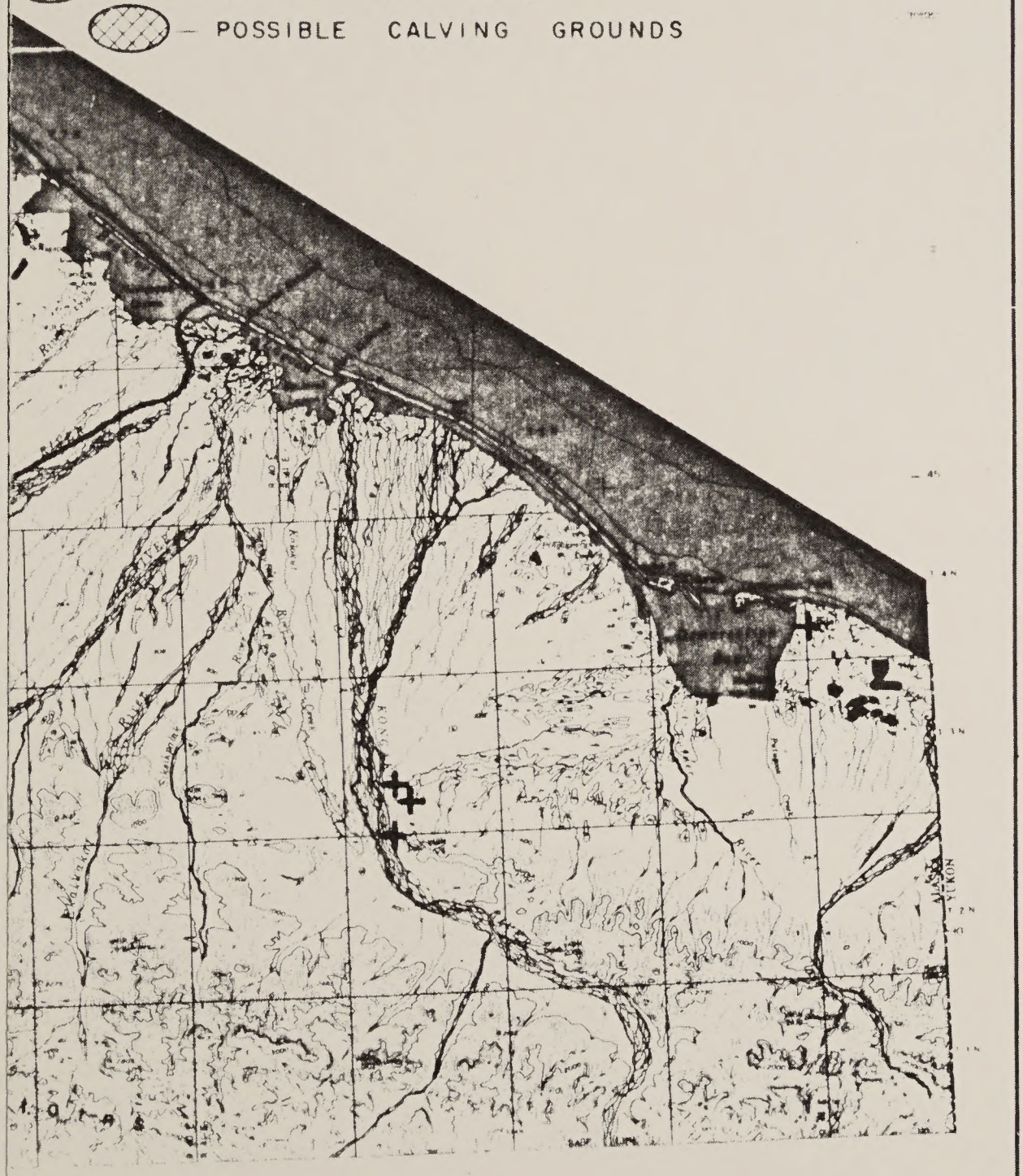
PRECALVING HERD LOCATIONS DURING ANNUAL CENSUS BY FWS 1978 – 1981

MUSKOX SIGHTINGS 1974 – 1981 (ROSENEAU AND BENTE, 1974 – 1977)

RANGE OF CANNING, SADLEROCHIT SPRINGS (JINGFORS, 1980) AND JAGO/OKEROKOVIK MUSKOX HERDS

CALVING GROUNDS OBSERVED BY JINGFORS 1978 – 1980

– POSSIBLE CALVING GROUNDS



Muskoxen (Ovibus moschotus)

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Muskoxen prefer riparian habitats. Willows are preferred, where they exist (see fig. B-28), although sedges and forbs make up a high proportion of the total food intake. Because the preferred food species are primarily associated with riparian habitats, the present distribution of most muskoxen is restricted to major drainages of the study area during all seasons (Lent, 1978).

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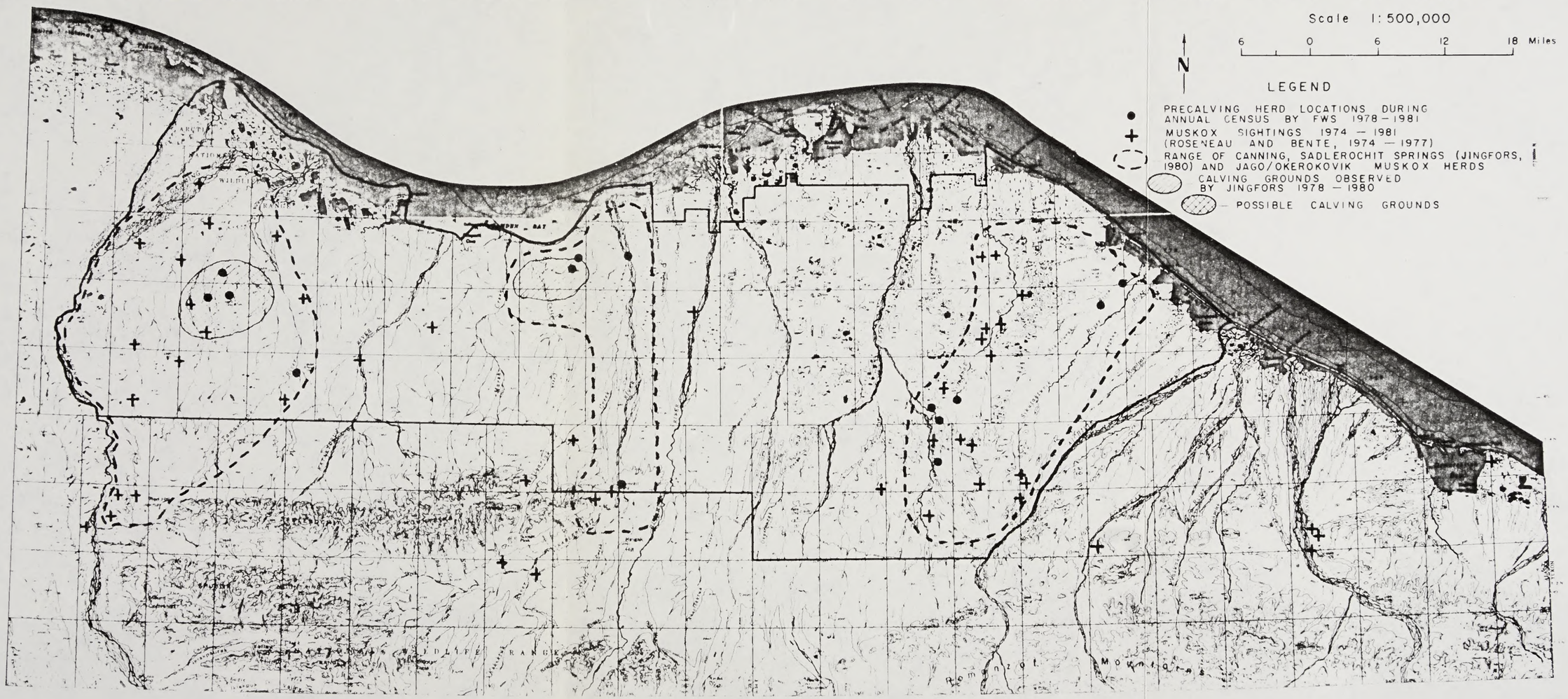
Calving occurs in late May or early June, after which a significant but unknown proportion of the animals disperse onto the coastal plain for the summer.

FIGURE III-15 MUSKOX DISTRIBUTION IN THE ARCTIC NATIONAL WILDLIFE REFUGE 1974 TO 1981


Scale 1:500,000
6 0 6 12 18 Miles
N
LEGEND
PRECALVING HERD LOCATIONS DURING ANNUAL CENSUS BY FWS 1978 – 1981
MUSKOX SIGHTINGS 1974 – 1981 (ROSENEAU AND BENTE, 1974 – 1977)
RANGE OF CANNING, SADLEROCHIT SPRINGS (JINGFORS, 1980) AND JAGO/OKEROKOVIK MUSKOX HERDS
CALVING GROUNDS OBSERVED BY JINGFORS 1978 – 1980
– POSSIBLE CALVING GROUNDS

In late August, moose begin to aggregate again in riparian habitats. Aggregation peaks in October during the rut. Some or all of a given population may move southward to overwinter in valleys of the Brooks Range. Riparian willow species comprise a major portion of the forage used by moose, with mountain alder being an important winter food item where available.

Dall Sheep (Ovis dalli)

Although the estimated total population of Dall sheep within the Arctic National Wildlife Refuge (before ANILCA additions) is approximately 6,800 (Smith, 1979), very few Dall sheep are found in the ANWR study area. The Sadlerochit Mountains, just outside the study area, contain an estimated 270 sheep (Smith, 1979), and constitute the northernmost extent of their range in North America.

Sheep are loyal to traditional winter and summer ranges and mineral licks. Summer range on ANWR consists primarily of alpine slopes and meadows. Winter range, limited mostly by topography, consists of windblown slopes and ridges, often with a southerly aspect. Dall sheep have been observed using the lower foothill terrain near Sadlerochit Springs, mostly in winter, but also in summer, as they cross the tundra to reach other habitats (Ross and Spindler, oral communication, 1981).

Wolves (Canis lupus)

Wolves are found throughout Alaska's North Slope, although population density is low on the coastal plain when compared to wintering areas farther south. They occupy large, stable home ranges and are not often observed in summer. In winter, wolves tend to congregate in areas of overwintering caribou and are more visible. Daily movement is dependent on availability of prey; Murie (1944) reported the typical stalk involved 10-15 miles.

Populations in or adjacent to the study area were depressed a few years ago by an outbreak of rabies. Density estimates for restricted geographic areas vary widely, but most fall within the range reported by Mech (1970) of 3 to 200 square miles per wolf. Mating occurs in March, and pups (usually four to seven to a litter) are born in dens 2 months later. Although wolves are known to den on the coastal plain west of the ANWR study area, no dens have been found in the study area itself, despite the fact that the basic habitat requirements for denning appear to be present.

Wolves prey principally upon caribou, moose, sheep, ground squirrels, birds, and microtines. Stalking of prey distributes wolves throughout all habitat types of the ANWR study area, but they are typically associated with major drainage systems.

Arctic Foxes (Alopex lagopus)

Arctic foxes range throughout the North Slope in two distinct seasonal movements. The first is in the fall and early winter months when they move toward the coast and onto sea ice, often traveling long distances. The second is around March and early April, when they return inland to mate and occupy summer dens (Chesemore, 1967).

Mating occurs in winter, and single litters containing 4 to 20 kits are produced in dens during May, June, or early July. More than 50 percent of the offspring may die during the first 6 months, depending upon availability of prey species. Life expectancy is 4-5 years (Fine, 1980). Kits appear above ground some time in June, and remain near the den until July or August, when adults start leading them on food-gathering trips.

Foxes are heavily dependent on lemmings for food. If lemmings are scarce, foxes readily compensate by increasing their intake of such alternates as birds and their eggs, ground squirrels, insects, and voles (Fine, 1980; Garrott, 1980). Arctic foxes are a significant predator on ringed seals when newborn seals are in the birth lair, and are opportunistic feeders on remains of polar bear kills.

Wolverines (Gulo gulo luscus)

The wolverine may be found throughout the North Slope but is considered scarce along the coast. Animals commonly travel along gentle slopes or stream edges, and they may be found searching for food in any habitat (Bee and Hall, 1956). Following breeding in late spring to summer (May-July), birth of two to four young occurs in late February or March in snow dens.

Wolverines are reported capable of capturing prey as large as moose, but carrion (primarily caribou and moose), when available, is considered the principal food. Ground squirrels, fish, rabbits, and microtines are also consumed (Rausch and Pearson, 1972).

The wolverine is noted for its avoidance of humans, its solitary, wide-ranging nature, and its sparse densities. Little is known about wolverines in the ANWR study area.

Brown Bears (Ursus arctos)

In northeastern Alaska, brown bear (grizzly bear) populations are especially sparse and home ranges (roughly 100 to 300 mi^2) are larger than for bears in other regions, probably due to a scarcity of food and cover. Within home ranges on the North Slope, willow thickets along river valleys are areas of concentrated activity. Daily movements typically range from zero to 5 miles.

ANWR personnel studying caribou also recorded brown bear observations in June of 1981. In general, brown bears appeared on the coastal plain in late May or early June, with the majority of sightings occurring during June and July. Seasonal distribution is believed to be a function of food availability. Bears range throughout river valleys in spring, mountain slopes in summer, and both areas in fall (Curatolo and Moore, 1975).

Breeding occurs normally during May through July. Denning in the Arctic typically occurs in October, and cubs (one or two) are born in the den in January or early February. The bears emerge in April and May.

Although brown bears are opportunistic feeders, vegetation is the dietary mainstay. Berries are favored in summer and early fall. Fish, caribou, and ground squirrels can be seasonal components of the diet in the study area. Reynolds (1979) stressed the significance of caribou availability during times when vegetation provides low levels of proteins. During their 6-month activity period, bears feed in the alpine tundra, foothills, and hilly coastal plain habitats more than in the remaining habitats of the study area.

Arctic Ground Squirrels (Spermophilus parryii)

The arctic ground squirrels are found throughout the ANWR study area in colonies restricted to well-drained soils which are free of permafrost. Ground squirrels are subject to severe climatic stresses and hibernate from late September through May (Baseline Study, U.S. Fish and Wildlife Service, 1982). Activity resumes in the spring, even before the snow has begun to disappear. Mating is followed by a short, 25-day gestation period, coupled with rapid growth of the young, since they must be prepared for the winter in a span of less than 4 months. Many animals do not survive the winter. An almost omnivorous diet allows them to take full advantage of the plants and available animal food. Ground squirrels play an important role as a prey item in the arctic food web.

Other Rodents

Other rodents occurring in the ANWR study area include collared and brown lemmings, and northern red-backed and tundra voles. Plant consumption along the coast is dominated by the brown lemming. Because brown lemming density varies cyclicly over a period of 3 to 5 years, grazing pressure is also cyclic. Lemmings remain active through the year, and maximum densities are attained after winter reproduction under the snow. Winter temperature interacting with snow depth and structure has major effects upon wintering lemmings. Shallow snow cover, providing relatively little insulation, creates an energetic stress for lemmings. Winter reproduction can be inhibited by low temperature and abnormally shallow snow.

Marine Mammals

Polar Bears (Ursus maritimus)

Polar bears are closely associated with the pack ice of the Arctic Ocean throughout most of the year. Considerable numbers of polar bears move to coastal areas and sometimes inland during autumn (October) when pregnant females seek den sites. Although pregnant polar bears, and later their cubs, are the segment of the population which spend the greatest amount of their time within the study area, other groups of polar bears seasonally frequent the periphery of the study area. Recapture of animals marked by the FWS in recent years indicates that an influx of sows accompanied by cubs up to 20 months of age and subadult animals coincides with the fall ice edge advance to the shoreline of the study area. The bears are believed to be scavenging on beach-washed carrion and are associated to a great degree with the carcasses of bowhead whales taken in the fall by the village of Kaktovik.

Polar bear dens have been found on land, offshore islands, shorefast ice, and drifting ice, from 169 km offshore from the coast to 48 km inland. The area along the coast from the edge of the shorefast ice to about 40 km inland, and from the Colville Delta to the Canadian border is used as the maternal denning area for the Beaufort Sea population of polar bears (fig. III-16). Areas within this zone which afford the most ideal denning conditions are riverbanks, draws, and the leeward side of bluffs where snow accumulation is sufficient to support den construction. Seven dens have been found within the ANWR study area.

Female polar bears that den on land move to the coast in October and November, the timing being dependent upon ice movement and the buildup of ice along the coast in the fall (Lentfer and Hensel, 1980). Denning females give birth to one to three cubs in December or January, and dens are opened in late March or April, depending upon weather conditions. The female and cub(s) generally remain near the den, making short forays for 1 to 2 weeks until the cubs gain strength and become acclimated to outside temperatures. Soon after, they traverse the shorefast ice to the drifting pack ice to feed primarily on ringed seals.

The Beaufort Sea is completely ice covered for almost 10 months of the year. The open water begins to freeze in September or October, and the nearshore ice does not melt until May or early June. With the exception of denning females, polar bears inhabit the ice throughout the winter. The distribution of polar bears over the sea ice is influenced by the abundance and accessibility of their major prey species, ringed and bearded seals. In winter, seals may be concentrated in areas of drifting seasonal pack ice where patches of open water form and then refreeze into areas of thin ice in which the seals can maintain breathing holes (Lentfer, 1971; Stirling, Andriashek, and others, 1975). Burns and Eley (1978) estimate that ringed seals comprise 95 percent of the polar bear's diet.

When the nearshore ice breaks up in spring, postdenning females and cubs, as well as immature and adult bears, move with the sea ice and tend to concentrate at the southern edge of the pack ice. This position varies seasonally but usually occurs between latitudes 71° N. and 72° N. off Alaska.

Polar bears are protected under the provisions of the Marine Mammal Protection Act of 1972.

Seals

Ringed seals (Phoca hispida), bearded seals (Erignathus barbatus) and, occasionally, spotted seals (Phoca largha) occur in the Beaufort Sea and along the coast north of the ANWR study area (Baseline Study, U.S. Fish and Wildlife Service, 1982). Their primary habitats are outside of the ANWR study area, although there is some evidence of ringed seal use of lagoon areas within the refuge in summer and fall. The extent of such use is not well documented, but it seems to be quite limited (U.S. Fish and Wildlife Service, 1982).

Whales

Bowhead whales (Balaena mysticetus) (figs. III-17, III-18) and belukha (beluga) whales (Delphinaplerus leucas) utilize the waters of the Beaufort Sea north of the ANWR study area during their migrations. Gray whales (Eschrichtius robustus) are occasionally or rarely found in the area (U.S. Fish and Wildlife Service, 1982). The

Scale 1:500,000

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LEGEND

● CONFIRMED DENS

◉ POSSIBLE DENS

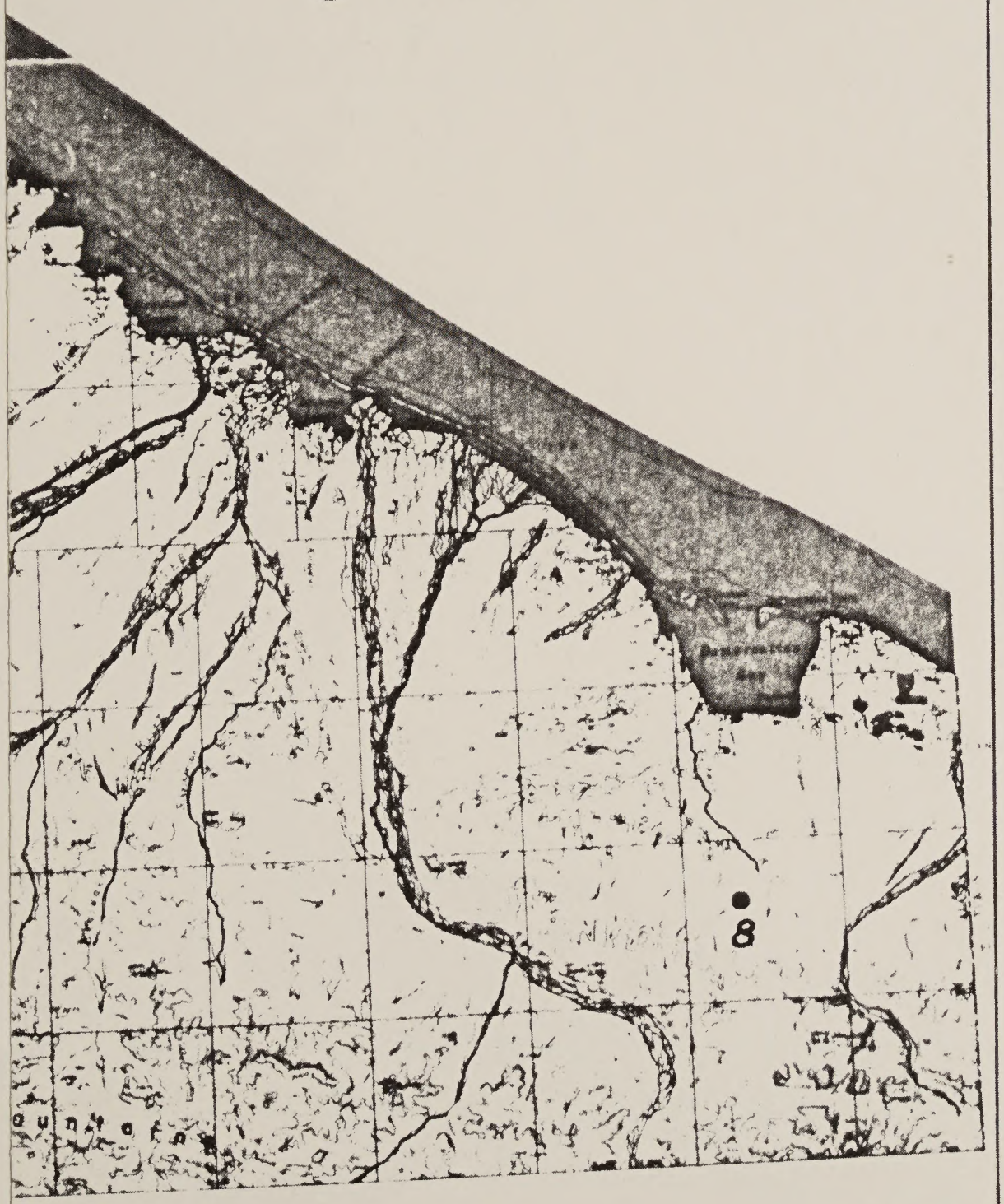

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FIGURE III-16 POLAR BEAR MATERNITY DENS

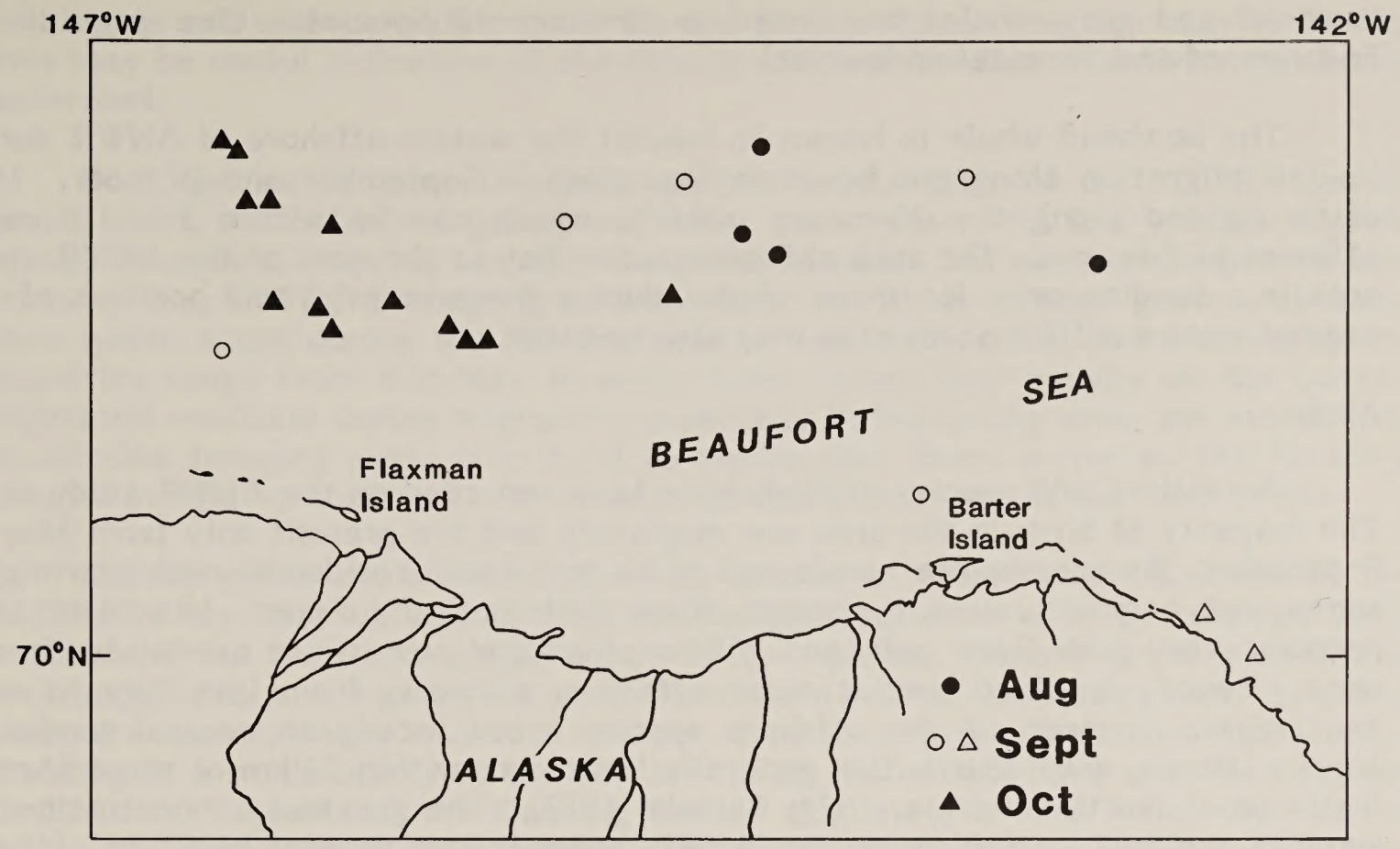

Figure III-17.--Locations of bowhead whales sighted during aerial surveys conducted by NOSC 1979. (Adapted from NOSC TD 314).

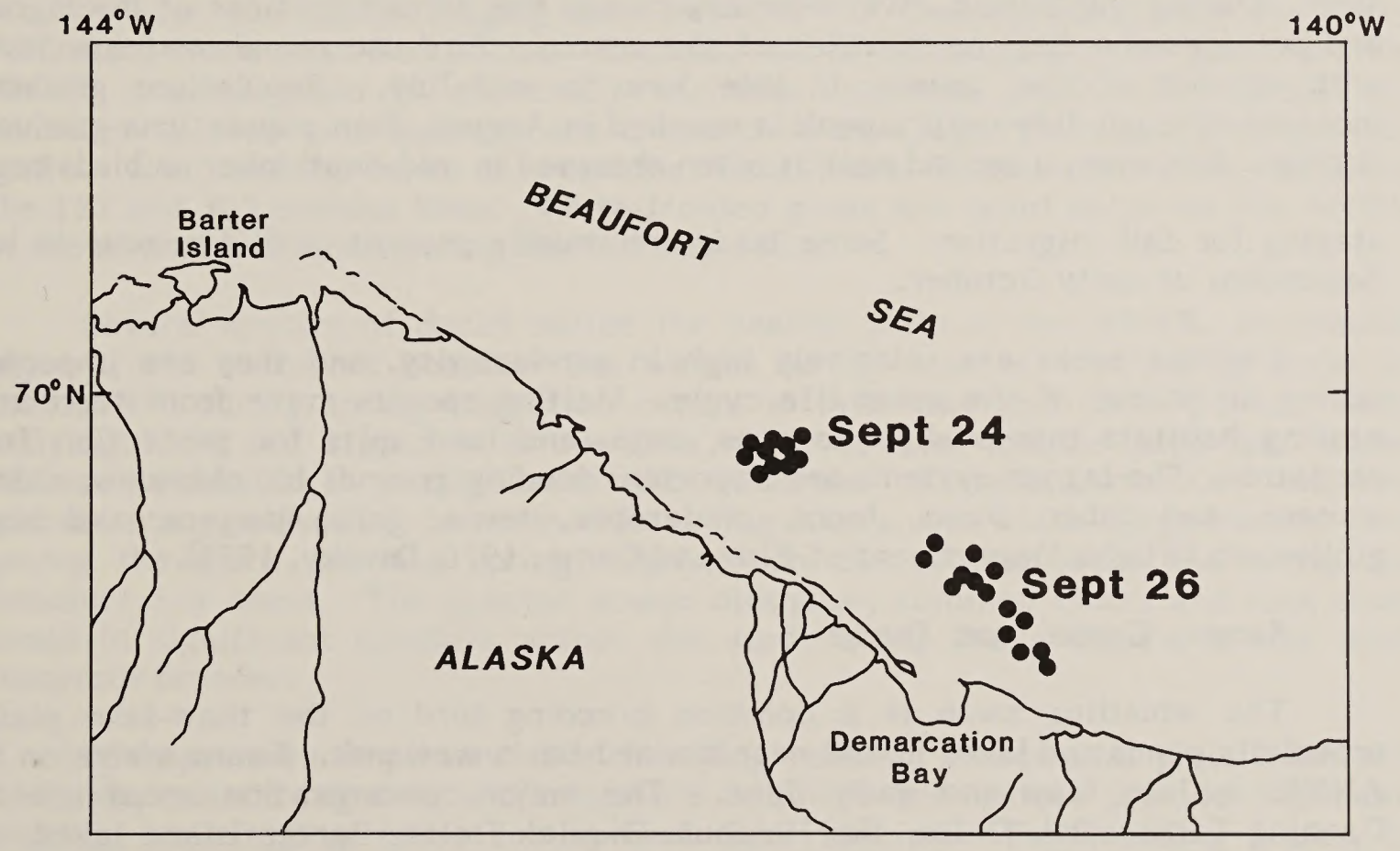

Figure III-18.--Enlarged view from figure III-17. September 1979 sightings of bowhead whales near Demarcation Bay. From aerial surveys conducted by NOSC 1979.

bowhead and gray whales are listed as Endangered Species. (See page III-24, Endangered and Threatened Species)

The bowhead whale is known to inhabit the waters offshore of ANWR during its fall migration along the Beaufort Sea coast in September and October. It is often sighted along the 20-meter isobath, which can be within 2 to 10 miles offshore in this area. The area of Demarcation Bay to the east of the ANWR study area is a feeding area for these whales during these months, and portions of the coastal waters off the study area may also be used.

Birds

A total of 108 species of birds have been recorded on the ANWR study area. The majority of birds in the area are migratory and are present only from May to September. Six species are considered to be permanent residents--rock ptarmigan, snowy owl, common raven, gyrfalcon, black guillemot, and dipper. In addition, the redpoll, ivory gull, Ross' gull, and willow ptarmigan sometimes overwinter in the area. Twenty-one bird species occur offshore, primarily from late July to mid-September. Sixteen of the offshore species breed locally on coastal tundra or barrier islands, with distribution generally limited to within 56 km of shore (Arctic Institute of North America, 1974; Bartels, 1973). The greatest concentrations of summer resident waterbirds on the ANWR occur in two general habitats: (1) the shallow coastal waters of the Beaufort Sea and (2) the tundra wetlands.

Birds begin to use coastal lagoons with the occurrence snowmelt in early June. During this period, river overflow covers the deltaic portions of the lagoons and provides the first open water of the season. Bird use remains at low levels until ice-out occurs, usually in late June to mid-July. Populations gradually increase through July until a peak is reached in August, then populations gradually decline. However, a second peak is often observed in mid-September as birds begin staging for fall migration. Some birds are usually present until freezeup in late September or early October.

Lagoons areas are relatively high in productivity, and they are important during all phases of the avian life cycle. Molting species move from terrestrial nesting habitats into shallow lagoons, bays, and land spits for protection from predation. The lagoon systems are important feeding grounds for oldsquaw, eiders, scoters, and other ducks, loons, phalaropes, terns, gulls, jaegers, and black guillemots (Alaska Department of Fish and Game, 1976; Divoky, 1978).

Swans, Geese, and Ducks

The whistling swan is a common breeding bird of the thaw-lake plains, especially ponds and lakes in and near drained-basin wetlands. Swans arrive on the ANWR in late May and early June. The major concentration areas are the Canning-Tamayariak Delta, the Hulahula-Okpilak Delta, Barter Island lakes, the Aichilik-Egaksrak-Kongakut Deltas, and Demarcation Bay lakes. These areas apparently offer the only highly desirable swan nesting and feeding habitat on the coastal plain within the study area. Swans begin departing the breeding grounds in mid-August, nonbreeders and failed breeders being the first to depart. Paired adults with young do not depart until the young can fly, which is probably as late as mid- or late September. Whistling swans are known to be sensitive to aircraft

overflights and surface traffic (vehicles and boats). Since they are easy to survey, they may be useful indicators of the effects of increased human activity on nesting waterfowl.

Four species of geese regularly use the coastal plain of the ANWR--Canada geese, brant, white-fronted geese, and lesser snow geese. All four species migrate by the thousands in spring and fall along the Beaufort Sea coast and adjacent land areas of the ANWR, although greater numbers of white-fronted geese and lesser snow geese occur during the fall migration. Reported arrival dates during spring migration range from mid-May to early June. Brant rely heavily on the coastal vegetated mudflats during migration, especially in the spring when the availability of suitable foraging areas is critical to ensure that brant arrive on the breeding grounds in healthy condition. Geese are especially abundant in the river deltas.

Canada geese and brant are the only species of geese known to breed on the ANWR. They nest on islands and peninsulas associated with the drained-basin wetlands of the thaw-lake plains and river flood plains. Canada geese with broods seek large lakes and lagoons for protection shortly after the hatch. Brant breeding areas are usually found near the mouths of large rivers. They have been found breeding in a small colony at the Okpilak Delta, and broods have also been sighted at Beaufort Lagoon and the Canning Delta. Beginning in late June, the Canada geese and brant which were nonbreeders or which failed to breed successfully migrate to the west to molt. Fall migration of geese begins in mid-August and continues through early September, although snow geese have been reported migrating as late as mid-October. Counts as high as 700,000 snow geese have been recorded for the entire staging area between the Canning River and the Parry Peninsula, Northwest Territories. Distribution of all staging snow geese on the ANWR coastal plain is extremely variable; however, two "core" areas are consistently used--one between the Okerokovik and Jago rivers north of the 305 contour line, and the other between the Aichilik and Sikutaktuvuk rivers between the 122 and 305 contour lines. White-fronted geese and brant occur on the ANWR in the tens of thousands during the fall migration.

Several species of ducks utilize the coastal plain of the ANWR, its coastal lagoons, and nearshore Beaufort Sea waters during summer. Arrival of ducks on the ANWR during spring migration occurs in late May and early June. Early arriving ducks are attracted to overflow water at river mouths until open water becomes available in nearby lakes and wetlands. Pintails, American widgeon, greater scaup, oldsquaw, common eiders, king eiders, and white-winged scoters are among the more common spring migrants on the coastal plain and along the Beaufort Sea coast. The greater scaup, oldsquaw, common eider, and king eider breed in significant numbers within the study area; the oldsquaw is the most numerous breeder.

Perhaps more important than breeding habitat, the coastal plain lakes and wetlands, coastal lagoons, and nearshore Beaufort Sea waters provide important molting and staging areas for several duck species. Postbreeding males, in particular, congregate in coastal lagoons, and nearshore waters and large open lakes during the mid-summer molt period and remain as summer residents. The movement of male oldsquaw and eiders from the ANWR coastal plain to the lagoons begins in early July. Movement of female oldsquaw and eiders continues through to late summer. Fall migration includes movement of females and juveniles, along with late-molting individuals, along the Beaufort seacoast. Many

of the postbreeding ducks that breed outside the ANWR utilize the coastal lagoons and nearshore waters as staging areas during the molt migration and fall migration.

Seabirds and Shorebirds

Seven species of seabirds are known to breed in the study area--three jaegers (pomarine, parasitic, long-tailed), two gulls (glaucous, Sabine's), arctic tern , and black guillemot. The jaegers are widely distributed over all habitat types, but their breeding populations are comparatively small. Likewise, glaucous gulls and arctic terns are also widely distributed, reaching greatest densities in tundra wetlands near the coast. Sabine's gull and black guillemots are highly localized. The only known nesting areas of the Sabine's gull in the study area are located on the Canning River Delta, whereas the black guillemot breeds only on the coastal beaches. Gulls, terns, and jaegers feed and nest along the coastline. Jaegers also feed on small birds and insects along the beaches, as well as on lemmings on the tundra (Baseline Study, U.S. Fish and Wildlife Service, 1982).

Shorebirds are present in the study area from about mid-May through the end of September. They inhabit all ecosystems of the ANWR coastal plain but are most abundant and predominant in the thaw-lake plains near the coast. On the coast, seasonal fluctuations in shorebird numbers are characterized by highs each year in mid-June (arriving birds), early July (nonbreeding transients), and late August (drifting, departing birds). It is estimated that over 2 million birds are present on the coastal plain from mid-June to mid-July (Baseline STudy, U.S. Fish and Wildlife Service, 1982). Fourteen species of shorebirds nest on the study area.

Raptors

Rough-legged hawk, golden eagle, gyrfalcon, snowy owl, and short-eared owl are all present on the ANWR coastal plain. The endangered arctic peregrine falcon is also present. (See Threatened and Endangered Species, below.) Rough-legged hawks nest on river bluffs and near steep foothill slopes; golden eagles nest in the foothills and the Brooks Range; gyrfalcons nest on the cliffs along rivers or on isolated upland cliffs; and owls nest on the open tundra. Raptors generally arrive on the ANWR in mid-May, except the gyrfalcon (a permanent resident) and begin nesting as early as the first week of April. Raptors prey upon small rodents, ptarmigan, waterfowl, and other birds, and their populations and distributions vary with the availability of prey. Snowy owl population peaks are directly related to the lemming cycles.

Upland Birds

The willow ptarmigan and rock ptarmigan are both common residents of the ANWR coastal plain. Willow ptarmigan breed in riparian willow habitats along rivers of the interior coastal plain and in sedge-tussock heath and dwarf shrub tundra of the outer coastal plain. They decrease in abundance northward near the coast, where dwarf shrubs become scarce. There is a general northward migration of willow ptarmigan in April and early May through the ANWR as flocks of several thousand birds move steadily from the Brooks Range north toward the coastal plain. Rock ptarmigan do not appear to undergo large-scale, long-distance migrations as do the willow ptarmigan. Following breeding and throughout the winter, there is frequently a segregation of ptarmigan by sex, with males using areas with a more rigorous cimate (higher altitudes and farther north).

Passerines

Many passerines, or perching birds, use the coastal plain of the ANWR during summer. Riparian willow stands support the highest numbers and diversity of passerine species. The redpoll, savannah sparrow, yellow wagtail, and tree sparrow are almost entirely restricted to riparian willow thickets or adjacent habitat types, such as riparian Dryas terrace or riparian gravel bars which also support willow growth. Lapland longspurs are one of the species nesting in highest densities on the wet sedge and upland dry sedge tundra types, and the only species reaching high nesting density in the upland tussock tundra. Only two passerine species are known to winter on the coastal plain of the ANWR--the raven, which is distributed throughout the area, and the dipper, which is probably restricted to the only open water available near Sadlerochit and Shublik springs.

Fish

Lakes are uncommon in the ANWR study area. Most of the lakes are located along the coast and are generally thaw lakes. Some deeper foothill and mountain lakes, such as Peters and Schrader lakes, supply streams that flow through the coastal plain. Coastal plain lakes less than 2 meters in depth generally offer unsuitable winter fish habitat. Many are shallow and either freeze to the bottom by late winter or offer poor water-quality conditions due to freeze concentration of dissolved solids and low dissolved-oxygen levels. Lakes near the ocean may also be brackish due to saltwater intrusion or windblown ocean spray. Some of these shallow coastal lakes may be important as summer feeding areas for many freshwater, anadromous, and marine fish. This seasonal use is dependent on a suitable outlet for access.

Several drainages originate in or transect the ANWR study area. These streams range from small tundra streams with intermittent flow to the Canning River with an estimated 50-year flood discharge of 13,500 cubic feet per second (Childers and others, 1977). Most of the water supply comes from precipitation, surface permafrost-thaw processes, deep-lake drain, and spring or ground water. Peak flows are associated with snowmelt in early summer or with rainfall during late summer and fall. By October, most arctic rivers cease to exhibit any measurable flow. As riffle areas freeze to the bottom, overwintering fish become isolated in deeper pools or spring areas. Winter flow through streambed alluvium is minimal or nonexistent. Ice accumulation on arctic rivers usually reaches maximum thickness between late March and early May.

Available overwintering habitat, such as deeper pools, is greatly reduced in early spring. Depth of these pools is important in their ability to overwinter fish; however, several other parameters affect their suitability for overwintering. These parameters ultimately affect dissolved-oxygen concentration and include density of organisms in the pool area, species' physiological tolerances, volume of the pool, temperature, organic matter, and the influence of springs. Overwintering habitat is perhaps the greatest limiting factor for arctic anadromous and freshwater fish populations (fig. III-19). Severe winter conditions in the Arctic drastically reduce available water supplies. During winter, overwintering water sources in streams are limited to spring areas, deeper isolated pools and brackish river delta areas.

Marine nearshore waters are important spawning and overwintering areas for many marine fishes, such as arctic cod and fourhorn sculpin. River deltas are believed to be important overwintering areas for many species of marine and freshwater fish. Arctic and least cisco have shown a preference for brackish waters of the Colville River Delta during winter. Suitability of delta overwintering areas depends on the salinity tolerances of species using the area.

Springs supply most, if not all, of the free-flowing water on the North Slope during late winter. Several springs occur within or drain through the study area. The importance of springs for spawning, rearing, and overwintering arctic fish populations has been well documented in other arctic areas. Little is known regarding fish overwintering locations on the ANWR; however, a large segment of the population is believed to depend on springs for winter survival. Springs are also essential to some species, such as arctic char, for spawning and rearing. The abundance and diversity of macroinvertebrates in springs and spring-fed sections of stream channels are generally much greater than in other arctic biotic habitats.

The distribution and abundance of fish in lakes within the ANWR study area has not been well defined. Lakes to the south and west of the study area contain populations of lake trout, arctic char, and grayling. Coastal lakes near the Canning River Delta have been sampled during summer and have contained grayling, arctic char, arctic cisco, round whitefish, broad whitefish, and fourhorn sculpin.

The Canning River has been studied more than any other stream in the ANWR study area. Fish species reported from this drainage include arctic char, grayling, round whitefish, broad whitefish, ninespine stickleback, chum salmon, and burbot. Distribution in other streams is not well defined. The only reported species in streams other than the Canning River are grayling and arctic char.

Nearshore waters of the ANWR have been reported to contain many marine and anadromous species, including arctic cisco, arctic char, boreal smelt, fourhorn sculpin, and arctic cod. Winter movement into shallower onshore water for spawning has been reported for Arctic cod in other parts of the Arctic (Ponomarenko, 1978). Subsistence use of Arctic cod during the winter occurs in apparent response to an increased winter abundance. Arctic cod (Lowry and others, 1978) comprises over 95 percent of diet of ringed seals.

Threatened and Endangered Species

Marine Species

The bowhead whales (Balaena mysticetus) and the gray whales (Eschrichtius robustus) are listed as endangered under the Endangered Species Act of 1973, as amended. Both species migrate into or through the Beaufort Sea, north of the ANWR study area. The occurrence of gray whales is extremely rare. In-migrations of bowheads occur beginning after spring breakup and out-migrations take place ahead of fall freeze-up. Residents of Kaktovik harvest bowhead whales during fall migration. Kaktovik hunters filled their quota of three whales in 1981 (U.S. Fish and Wildlife Service, 1982). Because the whales occur well offshore of the study area, no effect is anticipated (app. C); however, a biological assessment is being prepared in accordance with Section 7(c) of the Endangered Species Act (Public Law 93-205, Section 7(c), 87 Stat 892).

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LEGEND
KNOWN SITES
POTENTIAL SITES

Marine nearshore waters are important spawning and overwintering areas for many marine fishes, such as arctic cod and fourhorn sculpin. River deltas are believed to be important overwintering areas for many species of marine and freshwater fish. Arctic and least cisco have shown a preference for brackish waters of the Colville River Delta during winter. Suitability of delta overwintering areas depends on the salinity tolerances of species using the area.

Springs supply most, if not all, of the free-flowing water on the North Slope during late winter. Several springs occur within or drain through the study area. The importance of springs for spawning, rearing, and overwintering arctic fish populations has been well documented in other arctic areas. Little is known regarding fish overwintering locations on the ANWR; however, a large segment of the population is believed to depend on springs for winter survival. Springs are also essential to some species, such as arctic char, for spawning and rearing. The abundance and diversity of macroinvertebrates in springs and spring-fed sections of stream channels are generally much greater than in other arctic biotic habitats.

The distribution and abundance of fish in lakes within the ANWR study area has not been well defined. Lakes to the south and west of the study area contain populations of lake trout, arctic char, and grayling. Coastal lakes near the Canning River Delta have been sampled during summer and have contained grayling, arctic char, arctic cisco, round whitefish, broad whitefish, and fourhorn sculpin.

The Canning River has been studied more than any other stream in the ANWR study area. Fish species reported from this drainage include arctic char, grayling, round whitefish, broad whitefish, ninespine stickleback, chum salmon, and burbot. Distribution in other streams is not well defined. The only reported species in streams other than the Canning River are grayling and arctic char.

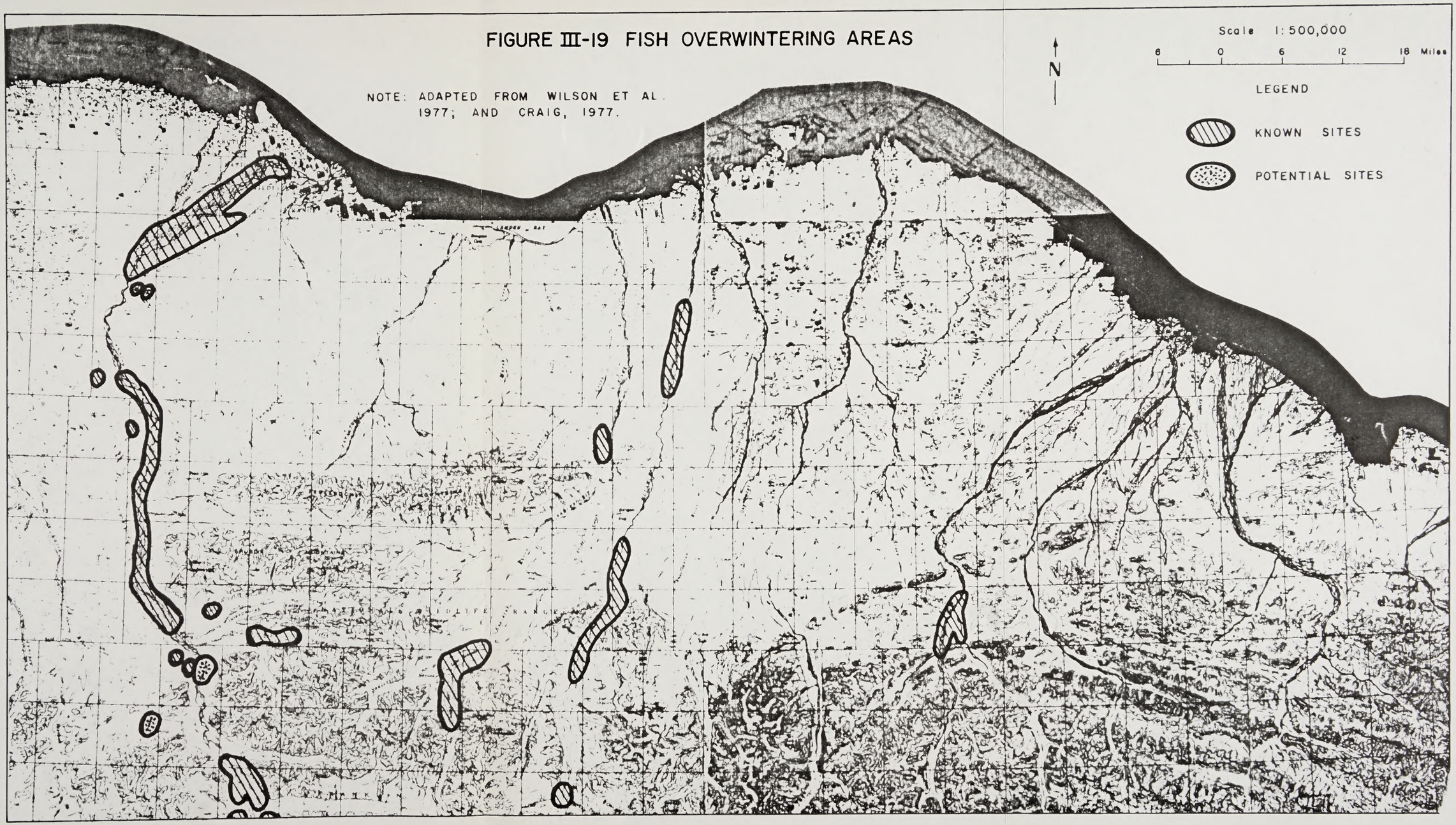
Nearshore waters of the ANWR have been reported to contain many marine and anadromous species, including arctic cisco, arctic char, boreal smelt, fourhorn sculpin, and arctic cod. Winter movement into shallower onshore water for spawning has been reported for Arctic cod in other parts of the Arctic (Ponomarenko, 1978). Subsistence use of Arctic cod during the winter occurs in apparent response to an increased winter abundance. Arctic cod (Lowry and others, 1978) comprises over 95 percent of diet of ringed seals.

Threatened and Endangered Species

Marine Species

The bowhead whales (Balaena mysticetus) and the gray whales (Eschrichtius robustus) are listed as endangered under the Endangered Species Act of 1973, as amended. Both species migrate into or through the Beaufort Sea, north of the ANWR study area. The occurrence of gray whales is extremely rare. In-migrations of bowheads occur beginning after spring breakup and out-migrations take place ahead of fall freeze-up. Residents of Kaktovik harvest bowhead whales during fall migration. Kaktovik hunters filled their quota of three whales in 1981 (U.S. Fish and Wildlife Service, 1982). Because the whales occur well offshore of the study area, no effect is anticipated (app. C); however, a biological assessment is being prepared in accordance with Section 7(c) of the Endangered Species Act (Public Law 93-205, Section 7(c), 87 Stat 892).

FIGURE III-19 FISH OVERWINTERING AREAS



Terrestrial Species

Of the five listed terrestrial endangered species in Alaska, only the arctic peregrine falcon (Falco peregrinus tundrius) is known to occur in the ANWR study area.

Although arctic peregrine falcons have been observed using a variety of sites for nesting, most eyries in Alaska are located on cliffs or bluffs overlooking rivers or bodies of water. Peregrine falcon nesting habitat is not abundant north of the Brooks Range in the ANWR. However, a limited number of peregrines have been reported nesting there in past years (Cade, 1960; Roseneau and others, 1976). Historically, peregrines have been known to occupy eyries along the Canning, Katakturuk, Sadlerochit, Hulahula, Jago, Aichilik, and Kongakut rivers. The most recent survey of raptor habitat in the ANWR found no nesting peregrines (Roseneau and others, 1980). This survey was conducted in August, however, and may have missed peregrines which attempted to nest but were unsuccessful. Among the eyries formerly or potentially occupied by peregrines within the ANWR, only two are within the Arctic coastal plain study area--on bluffs or cliffs along the Sadlerochit and Jago rivers.

Peregrine falcons are highly migratory and spend a relatively short period in Alaska. Arctic peregrines generally arrive at their North Slope eyries between April 21 and May 7; egg-laying and incubation occur between May 15 and July 21; the young leave the nest during August.

There appears to be a significant movement of arctic peregrine falcons through the study area on the Arctic coastal plain from late August to mid-September (Martin and Moitoret, 1981). The number and timing of these observations suggests that at least some North Slope arctic peregrines are following a coastal migration route along the Beaufort Sea, where large numbers of shorebirds and waterfowl (favored prey) concentrate in the lagoons, river mouths, and bays.

Although the last documented nesting of peregrines in the ANWR study area was in 1972-73, when three sites near the confluence of the Marsh Fork and the Canning River were occupied (Roseneau, 1974), several more sightings during June and July have been reported from the Arctic coastal plain. These observations do indicate that, in addition to those birds present during migration, a few scattered peregrines are present in the coastal plain during the breeding season.

In accordance with Section 7(c) of the Endangered Species Act of 1973, as amended, a biological assessment is being prepared.

Unique or Critical Areas

Section 1002(d) of ANILCA requires that the proposed regulations governing the exploratory activities identify periods in which human activity may have adverse effects, and designate temporary or permanent closing of such areas as appropriate. The proposed regulations identify provisions in an "Environmental Protection" section which allow the Regional Director, U.S. Fish and Wildlife Service, to designate zones and periods of restricted activity. Additionally, provisions allow the Regional Director to impose terms and conditions in any speical use permits authorizing exploratory activities which will further insure protection of critical areas.

Summer is clearly the period when wildlife sensitivity is the greatest due to their numbers and broad distribution. Winter is the least sensitive period, with waterbirds and the Porcupine Caribou Herd absent, and other large mammals relatively scarce in many areas. However, several areas within the coastal plain are important to the welfare of muskoxen and denning polar bears. Sadlerochit Spring is considered unique because of its large discharge and constant temperature, which maintains an open channel for nearly 8 km downstream during the coldest part of the year. Several plant and bird species not found anywhere else this far north are associated with this spring. The proposed regulations identify four special use areas and specify their location, period of control, and restriction. These areas include muskoxen calving special use area, polar bear denning special use area, Sadlerochit spring special area and caribou calving and postcalving special area. Further discussion of provisions in the proposed regulations regarding speical use areas are contained in chapter IV and appendix A.

HUMAN ENVIRONMENT

Socioeconomics

Population

The 1980 U.S. Census listed Kaktovik's population as 165, a 34-percent increase over the 1970 population. The population is primarily Native Inupiat Eskimo, with 18 of the 165 residents being non-Native (U.S. Department of Commerce, 1982). The population increase since 1970 has been the result of residents formerly living in Barrow who have returned to the village because of improved housing and employment opportunities. Kaktovik has survived as a community because of family and cultural ties, ties to the land, and the economic opportunity for both jobs and subsistence. Community growth will probably continue if current trends for services and other village improvements continue (U.S. Bureau of Land Management, 1978).

Subsistence Land Use

Most of Kaktovik's present subsistence land use is within the ANWR, extending as far south as the headwaters of the Hulahula River. The coastal area west of the refuge may also be used during summer, often to Bullen Point and occasionally as far as Foggy Island Bay.

Kaktovik residents depend primarily on caribou, Dall sheep, bowhead whales, fish, waterfowl, and other birds for their subsistence. Seals, polar bears, and furbearers and small game are secondary species. Brown bears and moose are occasionally taken. A few residents harvest berries, wild rhubarb, and roots. Driftwood is gathered from the beach and used as a supplementary heating source, and willows are an important heating and cooking source when camping.

Overall participation in subsistence activities is greatest during spring and summer months, as this is the time of long days, mild weather, and species abundance. During the snow-free months, usually mid-June through September, overland travel is not possible. Shallow water prevents access to inland areas by river; however, by early July, coastal areas are accessible by outboard-powered boats. From October through May, snow cover and frozen ground greatly expand the area used for subsistence. Long days combined with adequate snow cover and milder weather make April and May the best months for snowmachine travel.

Travel then extends across the tundra of the coastal plain and to hunting camps along the Hulahula and Sadlerochit river drainages of the Brooks Range. During winter, foothills and mountain valleys are the most important places for subsistence activities.

Caribou is the staple and most preferred land mammal in the Inupiat subsistence diet. It is a source of fresh meat throughout the year, and is also frozen and dried for later use. It is an important part of the holiday feasts. The hides are used for garments, boot soles, and blankets.

Caribou hunting opportunities and harvest are usually greatest from early July to late August, but can fluctuate widely depending on the sea ice conditions and movements of the animals. At this time of year, they are hunted primarily along the coast from outboard powered boats. Other important hunting periods are from late October to late November, when there is enough snow for overland travel by snowmachine and the daylight hours are not yet too few, and again from late February through March and April, when daylight is longer and weather conditions are better. No exact harvest data are available, but village leaders estimate that the average yearly take is 100 animals.

Most winter caribou hunting occurs in the mountains along river valleys. Occasional hunting occurs on the coastal plain, especially at favored locations such as Konganevik Point. The Hulahula River is one of the most intensely used areas for winter caribou hunting, and the Okpilak River and Okpirourak Creek drainages are also important hunting areas in winter. Some winter hunting is also done along the Jago and Niguanak rivers, the Niguanak Hills, and the Niguanak Ridge area immediately to the south.

In spring, caribou hunting continues in the Hulahula, Sadlerochit, Okpilak and Jago rivers winter-use areas. The greatest expanse of hunting territory is covered at this time of year. Occasional trips are made up the Okerokovik River and to the foothill country of the Aichilik River. Occasionally, in late winter or early spring, people travel to the Canning River in the vicinity of Ignek Valley and Shublik Island and hunt caribou as far upriver as the Marsh Fork.

Dall sheep hunting generally occurs from mid-October until mid-December. The Hulahula River drainage within the mountains is the most intensely hunted area. Hunting begins at the river's exit from the mountains near the 2d Fishing Hole and continues to the headwaters. The Sadlerochit River, creeks along the eastern side of the Shublik Mountains and Third Range, and the Whistler Creek area at Neroukpuk Lake are other locations where sheep are occasionally hunted. During recent years there has been increased hunting in the upper Okpilak, Jago, and especially, the Aichilik River drainages.

The number of sheep taken by Kaktovik hunters has fluctuated greatly, with only a few killed in some years to as many as 50 in other years. The harvest varies, depending on the success of the whaling season, the number of caribou available, snow cover, weather, and traveling conditions in the mountains.

Expanding muskoxen populations are likely to become a source for subsistence hunting in the near future.

Bowhead whales are actively hunted. In 1981, the village hunters fulfilled their quota of three whales as provided under conditions of the Endangered Species

Act of 1973 and the Marine Mammal Protection Act of 1972. Kaktovik's bowhead whaling season occurs during the westward migration of bowhead near the Beaufort Sea coast, from late August until early October. There is no spring whaling season in Kaktovik because the leads (open water) are too far from shore. Whale hunting is generally done within 10 miles of land but can extend as much as 20 miles offshore of Barter Island. After a whale is butchered, the meat and muktuk is divided among the captain, crews, and the rest of the village. Whaling is viewed as one of the village's most important annual activities. It stresses the cultural values of large group cooperation and sharing of resources, and is a way of passing these values to the younger generation.

Arctic char is the fish species most extensively used by local people. After the ice goes out in early July, sea-run char are caught all along the coast, around the barrier islands, and along the navigable portions of the river deltas. Char is the first species caught in the nets after the ice goes out, and they continue to be caught into late August. Arctic cisco is the most commonly caught whitefish species and is taken in the ocean by netting or seining. They begin appearing in the nets about the first of August, after the arctic char run peaks.

Willow and rock ptarmigan are hunted year-round, with greatest success during April and May when the birds congregate in large flocks. Waterfowl, especially black brant, are hunted along the coast, mostly in the spring from May through early June, although less intensive hunting continues throughout the summer and into September. People also commonly hunt common eider, king eider, snow geese, Canada geese, pintail, and oldsquaw. More oldsquaw are taken than any other species, although they are usually taken incidental to other forms of hunting or when fishing nets are checked. A small number of bird eggs are collected each spring.

Kaktovik people hunt bearded, ringed, and spotted seals for their oil, meat, and skins. Seal oil is an important element in the Inupiat diet and is also used for storing and preserving food (Wentworth, 1979a). Seals are hunted throughout the year, although relatively few are taken since their meat is no longer necessary to feed dog teams. Most seal hunting occurs by boat along the coast from July into September. At other seasons, hunters travel by snowmachine and search for seals along open leads.

Some residents of Kaktovik trap in the foothills for wolves, wolverines, and red and cross foxes. Others concentrate on Arctic foxes on the coastal plain. Furs are used locally in making parkas and ruffs or are sold to the Village Corporation or to fur buyers.

In recent years, most polar bears have been taken incidentally as a result of their intrusion into the village of Kaktovik. They are actively hunted on the ice, seaward of the barrier islands. The main hunting area for polar bears extends from the Hulahula-Okpilak River Delta on the west, to the Pokok Lagoon on the east. Hunting is often best near decaying bowhead carcasses. Harvest varies considerably from year to year.

Brown bears are taken by villagers strictly on an opportunistic basis (Jacobson, 1980), recently about two per year. Moose are also harvested on an opportunistic basis and are most often taken in the Sadlerochit Valley and in the foothills along Old Man Creek, Okpilak River, and Okpirourak River. Arctic ground squirrels are hunted mainly from March through May along the banks and sandy

mounds of the major rivers, especially the Jago, Okpilak, Hulahula, and Sadlerochit (Jacobson and Wentworth, 1982).

Village Political and Economic System

Kaktovik was incorporated as a second-class city in 1972 and has a council-mayor form of government, with the mayor appointed from the seven-member council. The city government exercises fire protection powers and provides recreational facilities to the community. The North Slope Borough, also formed in 1972, is the regional government entity and has all other public service powers allowed under State statute. The city does not levy any form of tax at this time (Arctic Environmental Information and Data Center, 1978).

The Kaktovik Inupiat Corporation, the village profit corporation formed as a result of the Alaska Native Claims Settlement Act (ANCSA) of 1971, had 112 original stockholders, including the Native residents of the village. It was allotted surface rights to 92,162 acres of land located entirely within the boundaries of ANWR. The corporation operates the small village store and sells fuel oil, aviation fuel, and snowmachines (Arctic Environmental Information and Data Center, 1978).

Kaktovik residents are also shareholders in the Arctic Slope Regional Corporation (ASRC), the regional profit corporation organized under ANCSA. The corporation administers settlement lands and funds for shareholders and is involved in various business activities, such as construction and communications.

The contemporary Kaktovik economy is a merger of subsistence and monetary elements, both operating within the Inupiat cultural context (Wentworth, 1979a). The North Slope Inupiat people have been living in a combined subsistence and cash economy since the late 1800's. Prior to this, they were seminomadic, living at various sites along the coast and traveling in pursuit of fish, game and furs. Since establishment of the DEWLine Station in the late 1940's, wage employment opportunities have allowed them to adopt the lifestyle of a permanent village. Former dwelling places, called Traditional Land Use Inventory Sites by the North Slope Borough, and fishing places are used seasonally for hunting and fishing as time permits. The old lifestyle remains important to villagers.

Since passage of ANCSA in 1971, and the formation of the North Slope Borough in 1972, many more jobs, amenitites, and other changes have come to Kaktovik. The many outward changes, however, have not resulted in significant changes in socio-cultural values. The economic system continues to operate through the kinship ties of the extended family and the values of the Inupiat hunter-gatherer society. Sharing of resources and group cooperation are very important. Wage earning is considered important as a means of buying better hunting equipment to become more successful hunters. A man's standing within the Native community is directly related to his success as a food gatherer.

One reason these socio-cultural values remain intact is that, despite rapid growth of the village, the surrounding landscape has not changed appreciably. People can still return to traditional camping, hunting, and fishing sites and pursue traditional activities in familiar settings, with maximum cultural privacy (Jacobson and Westworth, 1982).

Since the early 1970's, the North Slope Borough and the borough-funded housing and public building construction have replaced the DEWLine site as the

major employers in Kaktovik. Unemployment is not currently a problem in Kaktovik; the volume of the Borough's Capital Improvement Program has flooded the village with jobs (North Slope Borough OEDP Plan, 1981). However, underemployment is common (U.S. Bureau of Land Management, 1978, p. 450). According to an Alaska Consultants study, the Kaktovik workforce is 30 percent local and 70 percent imported (U.S. Bureau of Land Management, 1978, p. 450). Employment usually peaks in summer and fall, since much of it is construction related. Both men and women are employed in construction projects. Unemployment could become a problem as the North Slope Borough tax revenues from Prudhoe Bay oil development decline.

Average household cash income in Kaktovik in 1977 was estimated at about $16,700; the average Kaktovik household had 4.4 people (Institute of Social and Economic Research, 1981). Figures on household incomes, however, have less meaning in a culture where the extended family is the economic unit, and resources are so widely shared (Worl, 1979).

Subsistence, despite its cost in equipment and time, serves as a form of income to Kaktovik villagers inasmuch as there is no adqeuate substitute for harvested food that can be purchased. The price of imported food in the local store, the inconsistent availability of imported foods, and the lack of locally available fresh grocery meat and produce at any price add an additional incentive to subsistence hunting (Jacobson and Wentworth, 1982).

Public Services and Facilities

Kaktovik is in the North Slope Borough School District. The school complex consists of a two-classroom elementary school and a four-classroom high school, library, gym, swimming pool, and kitchen. The school site also contains five teacher housing units, two storage buildings, a playground, and a school maintenance shop. The school serves as a recreational facility providing classrooms, gym, and library for local use. A vocational education building is being constructed (North Slope Borough, 1980). Kaktovik school enrollment for 1981-82 was 54 students, 42 being in junior high and high school.

The Presbyterian Church at Kaktovik plays an important civic, social, and cultural role in the community. An Inupiat-speaking minister and village lay ministers conduct Sunday and Wednesday night religious services, marriages, funerals, and baptisms.

Kaktovik has a health clinic staffed by a health aide who maintains radio and telephone contact with the Public Health Service hospital in Barrow. Two officers from the North Slope Borough Department of Public Safety are stationed at Kaktovik and operate the public safety building, which includes a jail. Federal government-operated facilities in Kaktovik consist of the U.S. Post Office and the U.S. Fish and Wildlife Service ANWR field office. A Federal Aviation Administration employee and a U.S. Weather Service employee work at the DEWLine Station.

The community's only airport is operated by the Air Force at the DEWLine Station, and only aircraft approved by the Air Force 48 hours in advance can land there (Arctic Environmental Information and Data Center, 1978). The Air Force

recently closed the airport terminal to the community and the public. A village terminal is proposed through the borough's Capital Improvements Program (North Slope Borough, 1980).

Two scheduled bush air carriers serve Kaktovik from Fairbanks, and one from Barrow. Although flights are scheduled several times weekly, they are commonly cancelled because of inclement weather. Kaktovik has an air taxi service that operates charter flights to other Arctic communities, to Fairbanks, and into the ANWR. A supply barge comes to Kaktovik once a year in August. Privately owned small boats are used for traveling to subsistence areas and occasionally to other communities during the ice-free season. In winter, snowmachines are used. People travel on the village's gravel road system with pickup trucks, motorcycles, and snowmachines in winter.

Prior to 1974, most housing in Kaktovik was constructed by individuals using plywood or secondhand quonset hut materials obtained from the DEWLine Station. In 1974, eight prefabricated units were constructed under the Alaska State Housing Authority Remote Housing Program. The North Slope Borough assumed control of the village housing construction in the late 1970's, and since 1978 approximately 20 new, larger, and better insulated houses have been built (U.S. Bureau of Land Management, 1978) to replace substandard existing housing. When a family moves into a new house, their old house is rented, occupied by a grown son or daughter, used for storage, or torn down. Housing demand is high even though the new units have decreased the number of persons per unit.

Kaktovik residents now have telephones in every home, through the Arctic Slope Telephone Association Coop. People receive satellite television through the State network, and radio from a Barrow station. Electric power is furnished to homes by five diesel generators. Borough-operated trucks deliver water and provide sanitation services for each dwelling.

Military Uses

In 1947, the U.S. Air Force established the Bar Main Distant Early Warning (DEWLine) Station and airport on Barter Island. This was part of a larger network or radar installations established along the Arctic coast. The establishment and expansion of the site forced the village of Kaktovik to relocate three different times, but also brought wage employment opportunities to villagers. The site is located about 1 mile from the present village and is largely self-contained, functioning as a separate entity from the village. Up to 70 employees live at the site. The site employs three local Inupiat and two non-Inupiat citizens who live in the village.

Archeology

Only very limited, non-intensive historic and archeological resource survey has taken place within or immediately adjacent to the study area. As a consequence, any discussion of the nature and extent of these resources and related cultural history must be considered preliminary, subject to revision as the data base is expanded and better understood, and based upon tentative conclusions of extensive, non-comprehensive survey. Gaps in the data base leave open numerous questions about the sequence of human occupation of the area, the cultural and environmental processes that produced the sequences, and the systems of settlement that organized the successive populations that occupied the study area

and its environs. At present, any attempt to establish a chronology for the study area involves balancing a number of discrepancies. Thus, it is not known when the first inhabitants came into the area (estimated anywhere from 6,000 to 12,000 years ago, or possibly more), or what their sites might contain or look like, but the scant data that do exist indicate a broad series of known and unknown cultural groups succeeded them through time until the present. (See table III-4.)

In general, there is reason to believe that contacts between adjacent portions of Alaska and eastern Siberia were frequent, if not continuous, during much of the late Pleistocene, because these regions were relatively free of ice during the last glaciation and also were united by a land bridge across which animals and men could range. Archeology confirms these contacts continued into recent times. These early entries resulted not only in the initial peopling of the Arctic, but also of the entire Western Hemisphere (Chance, 1951). Potentially, habitation could have occurred continuously or intermittently from early Paleoindian times through current Eskimo occupation. The cultural resource traces left behing include an understandably wide range of artifacts, tools, worksites, villages, campsites, burials, tent rings, storage areas, corrals, rock art, housepits, trading posts, weapons, and possibly shipwrecks, and more (Hall and Gal, 1982). Due to the fragile nature of the cultural record, most of these non-renewable resources have been reduced to archeological remains. The study area is believed to be within one of the two most probable entry routes for the first human inhabitants of the Western Hemisphere from the mainland of Asia (Solecki, 1951; MacNeish, 1956; Irving, 1971).

Archeological research, of sorts, has been carried out in north Alaska since the late 19th century. Prior to this time, as early as 1826, explorers, prospectors, whalers, traders, and natural scientists entered this region, and their journals and notes provide some information on the lifeways of the Makenzie Eskimo before they were permanently changed by intensive contacts with the Europeans (Chance, 1951; Dekin, 1973).

The first archeological survey conducted in the study area covered the seacoast from Flaxman Island at the mouth of the Canning to Barter Island (Giddings, 1954). This survey located only one small prehistoric mound and an unreported number of historic sites. The mound, partially eroded by the sea, is described as a single half-underground house with a shallow midden surrounding it. The styles of bow frames, arrow stems of antler, sealing darts, and other artifacts indicate the site may be earlier than Ekseavik, which is dated to the late 14th and early 15th centuries on the basis of tree-ring dating (Giddings, 1952).

The divide between the Kongakut and Firth River drainages, Mancha Creek, a tributary of the Firth River, and a 40-mile stretch of the upper Kongakut River were superficially covered by a survey in 1953 (Ricciardelli, 1954). Several caves located 400 to 800 feet above the valley floor were examined and found to be sterile of cultural evidence. Creekbanks, old terraces, weathered ridges, willow patches, confluences of tributary streams, and other favorable spots were examined for prehistoric sites, but no cultural evidence was found. However, several sites associated with gold mining were located, but no details wer reported by Ricciardelli (1954).

During the summer of 1961, a survey was made in the vicinity of Peters and Schrader lakes and in the foothills and valleys of the Shublik and Sadlerochit Mountains immediately to the north and west. A major objective of this study was

"to explore the unglaciated treeless tundra in this narrow constricted zone between the mountains and the sea * * * test the hypothesis that this was a natural route for prehistoric man through this part * * * (and) seemed to offer a logical and unimpeded low-level route for early man into North America" (Solecki and others, 1973, p. 1). Twelve discovered sites are considered prehistoric. Four are termed multicomponent, but none were stratified; components were identified by extracting artifacts that appeared to fit into cultural traditions that had been previously defined. One of these sites contained British Mountain, Denbigh Flint Complex, and Eskimo components. One consisted of British Mountain and Eskimo components, while another contained Denbigh and Eskimo artifact groups. One of the Denbigh sites had an unidentified component with it. The remaining prehistoric sites either yielded single components or were not identifiable; two were Eskimo, four were Denbigh, and three were unidentifiable. Seven historic tent rings were also located and mapped.

The FWS has been conducting archeological investigations on the ANWR for several years, as part of the on-going program to identify and evaluate cultural resources on Service lands. (See Wilson, no date.) Results are not completely analyzed, but some preliminary conclusions can be drawn. The investigations included the survey and limited testing of selected areas of the upper Hulahula River, the foothills around the Kongakut and Canning Rivers, and the coast in the Demarcation Bay and Barter Island areas. Other areas have also been visited. More than 40 archeological and historic sites have been identified which combine to potentially span a time period of the last 6,000 years. Unfortunately, the sites that may represent an early occupation have not yielded diagnostic artifacts or organic materials suitable for radiocarbon dating; thus, accurate dating is not possible.

At least two and possibly three Thule village sites have been identified in and adjacent to the study area. These sites are scattered along the coast, with one located at Barter Island, one at Arey Island, and one at Icy Reef in the Demarcation Bay area. Only the site at Barter Island has been dated, and this was through comparison by Jenness (1928) to the Stefansson collections from Barrow (Wissler, 1916). Unfortunately, very little remains of this site due to the construction of the airport on the island. Several sites located in the foothills have been very tentatively identified as from older Eskimo occupation (Wilson, no date).

Most of the Eskimo sites found during this survey were occupied some time during the last 200 years. They range in size and importance from a large semipermanent caribou hunting village with several associated burials, to concentrations of several tent rings or sod houses, some which have one or two associated burials, to caribou fences, and, finally, to single tent rings. One site at Turner River Overlook in the foothills and another in the Demarcation Bay area contained similar artifacts and may represent the occupation and food procurement loci of the same social group. Although the artifacts present in these sites suggest that they were occupied some time during the middle to late 1800's, there is no memory of them in the traditions of the people, most of whom are western Eskimo, presently living in Kaktovik. This fact, along with the report of Stefansson that most of the Mackenzie Eskimo had almost all died-out by the beginning of this century indicate that these sites may represent that last occupation by this group in northeastern Alaska (Wilson, no date).

Table III-4.--Provisional outline of north Alaska culture history

(After Edwin S. Hall, 1981)

Tradition	Culture	Date	Radiocarbon dates*	Representative sites
Eskimo	Historical Inupiat	1838-present	-----	Turner River Overlook. Prudhoe Bay #1, Barrow sites, Sisraruq, Tukuto Lake, Anaktuvuk Pass sites, Anigarnigurak, and many others.
	Late prehistoric Inupiat (Western Thule)	A.D. 900-1838 on coast; ca. 1300-1838 in interior.	Walakpa: 840±90 = A.D. 1110. Some radiocarbon dates from Alyeska Pipeline corridor may date sites occupied during this period.	Nuwuk and other sites around Barrow, Walakpa, Nunagiak, Agergognat, Liberato Lake, Swayback Lakes, Tukuto Lake, Lake Betty, Kinyiksukvik, Etivluk Lake, and others.
Athapaskan	Kavik (kutchi)	A.D. 1450-1850	Antigun: 115±140 B.P. = 1835; 360±100 B.P. = A.D. 1519; 310±140 B.P. = A.D. 1640; 168±34 B.P. = A.D. 1782, etc.	Kavik, Antigun.
Eskimo	Punuk	ca. A.D. 900	-----	Nunagiak.
	Birnirk	A.D. 500-900 on coast; interior apparently not dated.	Anderson Point: 1130±200 B.P. = A.D. 820; 1160±240 B.P. = A.D. 797: 1090±300 B.P. = A.D. 867. Kugusugaruk: 1430±90 B.P. = A.D. 527; 1146±95 B.P. = A.D. 811; 1430±190 B.P. = A.D. 520; 1146±95 B.P. = A.D.804. South Meade #1: 1260±65 B.P. = A.D. 690; 1340±55 B.P. = A.D. 610; 1420±110 B.P. = A.D. 530.	Anderson Point, Birnirk, and other sites in Barrow area, Walakpa, South Meade #1.
	Old Bering Sea	ca. A.D. 500	-----	Birnirk and other sites in Barrow area.
Arctic Small Tool	Ipiutak	A.D. 0 to A.D. 700; may have coexisted with Birnirk for some time.	Five dates on material from the Feniak Lake site, in the Noatak drainage, which is comparable to Anaktuvuk Pass Ipiutak, average A.D. 500.	Anaktuvuk Pass, Itkillik Lake.
	Norton	1500 B.C. to A.D. or slightly later.	Gallagher Flint Station: (Hearth 1) 2920±155 B.P. = 970 B.C.; (loc. 1A) 2620±175 B.P. = 670 B.C.; (loc. 5) 1975±125 B.P. = 25 B.C.; 2540±185 B.P. = 590 B.C.; (loc. 7) 1735±150 B.P. = A.D. 215; 2640±180 B.P. = 690 B.C.; and others.	Sites in Barrow area, BAR-095, Walakpa, Sisraruq, Avak Point, Tukuto Lake, Kayuk and Avingak in Anaktuvuk Pass, numerous sites along Alyeska Pipeline corridor including Gallagher Flint Station.
	Choris		Other radiocarbon dates from Alyeska Pipeline corridor may date sites occupied during this period. Dates on the brief Avingak occupation at Anaktuvuk Pass range from 1500 to 3000 years ago.	

Table III-4.--Provisional outline of north Alaska culture history--Continued

Tradition	Culture	Date	Radiocarbon dates*	Representative sites
Arctic Small Tool--Con.	Walakpa	ca. 1500 B.C.	Walakpa: 3400±520 B.P. = 1450 B.C.	Walakpa and Coffin.
	Denbigh	?2300 B.C.-500 B.C.?	Punyik Point: 3660±150 B.P. = 1710 B.C.; another date of 650 B.C. was discarded as being too late. No Name Knob: 3440±160 B.P. = 1490 B.C.; 3855±155 B.P. = 1905 B.C. Blip: 3480±180 B.P. = 1530 B.C. Mosquito Lake: five dates ranging from A.D. 20-40±150 to 880-900±165 B.C.; a sixth date (2040±170 B.P. = 0 B.C. is believed to be culturally invalid	Tukuto Lake, Karupa Lake, Etivluk Lake (Punyik Point), Anaktuvuk Pass, Mosquito Lake, and other sites along Alyeska Pipeline corridor.
Northern Archiac	Tuktu	?4500 B.C.-? area may have been uninhabited for a period before Denbigh times.	Tuktu: Seven dates range from 4500 B.C.-200 B.C., but earlier dates believed correct on basis of dated sites outside northern Alaska.	Tunalik, Tuktu, Lisburne, and sites along Alyeska Pipeline corridor (Cook, 1970).
Paleo-Amerind	Lanceolate Point	6000-5000 B.C.	Mesa: 7620±95 = B.C.	Kahurok, Mesa, Niayuk (Anaktuvuk Pass, Lisburne, Bedwell (putu site).
	Fluted Point	ca. 6500 B.C.	Putu: 6090±150 6090±150 B.P. = 4140 B.C.; 8454±130 B.P.; 11,470±500 B.P. = 9520 B.C.	Utokok River sites, Lisburne, Putu scattered finds elsewhere?
American Paleo	-----	ca. 8500 B.C.	Gallagher Flint Station: 10,540±150 B.P. = 8590 B.C.	Tunalik, Lisburne, Gallagher Flint Station, scattered finds elsewhere.

*Many of the radiocarbon dates presented are uncorrected and therefore may be slightly inaccurate.

Other sites found during the survey represent the remains of the Native and white communities that have moved into the area in the last 80 years (Wilson, no date). They have been discussed in the previous sections on Socioeconomics.

Stefansson (1914) indicated that Indians from the Arctic Village area used the Hulahula River as a travel route when attending the trade fair at Arey Island which Franklin (1828) may have observed, and it may be possible that future surveys on this river will identify Indian sites.

Summarizing the reports of the archeological investigations clearly confirms little is known of the archeology and early history of the study area and its immediate environs. The literature of the area is composed, largely, of unpublished preliminary reports and journals. Cultural chronology and interpretation of settlement systems are tentative for many interrelated reasons, including the vastness of the area, the complexities of the cultures, and the processes of change over at least 12,000 years. Thus, coverage has been in limited depth in limited areas. Sites have been reported but not excavated, or excavated but not reported. All surveys focused on areas where archeologists expected to find sites, but no studies have been conducted to test these settlement system hypotheses (Wilson, no date; Dekin, 1973).

The work of the FWS has led to the following preliminary conclusions about potential site locations:

Information evaluated thus far provides the following conclusions:

1. Although the density of sites on the ANWR is not as high as in areas to the west, it is still high enough to justify definite concern in management decisions.

2. Sites tend to be located on higher ground where wide panoramas are visible, or on modern or fossil riverbanks.

3. Sites appear to be particularly dense at the mouths of canyons where the foothills end and the coastal plain begins.

4. There are many sites on the coast.

5. No sites have been found in the mountains high above the Hulahula or Kongakut rivers, probably because of difficulty of access.

6. No sites have been found on the coastal plain at any distance from rivers (Wilson, no date).

The limited scope of archeological research in the study area leaves many questions about basic cultural occupation sequences, as well as the social processes and dynamics that produced the chronology, to be answered (Dekin, 1973; Wilson, no date). Future research in the study area will focus on the numerous aspects of these questions.

An extensive archeological reconnaissance of the coastal plain is proposed for the summer of 1982, to provide FWS with data for compliance with the National Historic Preservation Act of 1966, as amended, and the Advisory Council on Historic Preservation's implementary regulations, 36 CFR Part 800.

Recreation

Recreational use of ANWR is varied and is related to wildlife or wilderness values. It is relatively limited as a result of the remote location of the refuge.

The most common forms of recreation are hunting, floating rivers, and backpacking/hiking. Other recreational pursuits include wildlife observation, photography, mountain climbing, cross-country skiing, fishing, and nature study. Most recreationists involve themselves in a variety of these activities. Local residents also engage in snowmobiling and dog mushing.

Recreational use of the area has been slowly but steadily increasing with improvement of scheduled airline service to jump-off points and the expansion of guide and air taxi services. Recreational use is expected to increase with continued improvement of services provided by the private sector.

Wilderness

The coastal plain of the ANWR study area has not been classified as a wilderness area. Section 1317 of ANILCA requires that, within 5 years of enactment of the act, the Secretary of the Interior review as to their suitability or nonsuitability for preservation as wilderness units of the National Wildlife Refuge System in Alaska not already designated as wilderness. Following his report to the President, the Secretary is to advise the Congress of his recommendations with respect to such areas.

Wilderness is described by the Wilderness Act of 1964 (Public Law 88-557) as "an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain. * * * an area of undeveloped Federal lands retaining its primeval character and influence, without permanent improvements or human habitation, which is protected and managed so as to preserve its natural conditions and which (1) generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable; (2) has outstanding opportunities for solitude or a primitive and unconfined type of recreation; (3) has at least five thousand acres of land of sufficient size as to make practicable its preservation and use in an unimpaired condition; and (4) may also contain ecological, geological, or other features of scientific, educational, scenic, or historical value." With the exception of the human settlement of Kaktovik and the three military reservations located on the coast or on Barter Island, and the onshore inholdings of the Inupiat Corporation, the entire coastal plain of the ANWR study area meets the above description.

Two sites within or immediately adjacent to the study area have been recommended for inclusion in special recognition systems. The Sadlerochit Mountains and Warm Springs have been nominated for designation as a National Natural Landmark site. The goal of the National Natural Landmarks Program, established in 1963, is to inventory and characterize sites that best illustrate the diversity of our Nation's natural heritage. The approximate size of the site is 93,313 hectares. The Sadlerochit Mountains themselves lie outside the study area; the Sadlerochit Spring lies within the study area close to the southern boundary of the area. The nomination of this area was made because it contains the farthest north population of Dall sheep in North America and because of the warm water aquifer and lush vegetation (Bliss and Gustafson, 1981).

An additional site has been nominated for consideration for inclusion in a statewide system of Ecological Reserves. The Jago River drainage, according to Stenmark and Schoeder (1974), contains "a complete array of tundra and flood plain vegetation and animal types typical of the North Slope." The complete river drainage from headwaters to mouth is included in the proposal. A large portion of the Jago River drainage lies within the coastal plain study area.

Esthetics

The visual resource of the study area encompasses a broad diversity of ecotypes and landforms. The irregular coastline of the Beaufort Sea--characterized by its barrier islands, lagoons, beaches, submerged bars, spits, and river deltas--gives way to the south to the gently rising coastal plain.

Poorly drained and dotted with small lakes, ponds, and ice polygons, the coastal plain is incised by a multitude of streams and rivers draining northward to the sea. The backdrop of the steeply rising Brooks Range, with its deep river valleys and glacier-clad peaks, portrays the abruptness and rugged beauty of the area.

With the change of season comes a dramatic change in color, sound, and intensity of activity in the area. The dark, cold harshness of winter gives way to a short but intense growing season producing a lush array of wildflowers and low tundra growth. Stream channels and river courses become lined with the verdant growth of willows, and a variety of wildlife moves across the land. The postcalving caribou aggregation offers a spectacle of this type unparalleled in the Western Hemisphere. Muskoxen on the refuge occupy their only historical habitat in the State of Alaska.

CHAPTER IV

ENVIRONMENTAL CONSEQUENCES

This chapter discusses and analyzes the impacts or effects of each of the regulatory alternatives described in chapter II.

ALTERNATIVE 1. REGULATIONS AUTHORIZING GOVERNMENT-PRESCRIBED OPERATIONS

The purpose in developing extremely detailed regulations would be to provide the highest level of Government control with respect to exploratory activities. Prescription of detailed site-specific controls through formal regulations at this time could, however, handicap the ability of the Government to quickly react to and redirect exploration activities discovered to result in unanticipated adverse effects. Very detailed regulations could incumber the flexibility required for day-to-day guidance and control of exploration activities in contrast to the development of terms and conditions tailored to individual actions and onsite monitoring.

The impact analyses of the various exploration methods in the discussion of alternative 3, is generally applicable to impacts which would result from alternative 1. However, it is possible that stringent-regulatory incumberances under this alternative could result in impacts in instances where the ability to react quickly to unanticipated consequences of exploratory activities is impaired. This alternative could prevent an adequate assessment of the coastal plain and thereby result in insufficient data regarding oil and gas resource potential if the Regional Director precludes or restricts exploration activities in a substantial number of areas.

ALTERNATIVE 2. REGULATIONS AUTHORIZING APPLICANT-DEFINED OPERATIONS

As described in chapter II, this alternative would consist of promulgating regulations providing only minimal guidance from which an applicant would develop an exploration plan to ensure compliance with the standards set forth in Section 1002(d)(1) of ANILCA. The advantage of very general regulations is that optimum flexibility would be provided the applicant for developing an exploration plan. This would allow the applicant to tell the Government how and when operations would be conducted. It is likely that more of the ANWR study area will be explored.

There are several significant disadvantages related to this approach. With no specific common basis for development of exploration plans, there could be extreme variances in the types of plans submitted for Secretarial approval. Evaluation of the plans to determine their consistency with the regulations and the act would be more subjective than it would be under alternatives 1 and 3. Because this alternative would provide less criteria for determining whether the plans are consistent with the regulations and the act, more exploration plans are likely to be approved. More approved plans could result in more exploration activities, some being conducted concurrent with or in duplication of others, which would therefore increase the possibility of significant adverse impact. Because onsite FWS monitoring would be relied upon as the primary means of controlling impacts, it is likely that impacts would begin to occur before they could be avoided or stopped

and an activity modified or halted. Also, coordinating such a comprehensive monitoring effort lends itself to the increased opportunity for inconsistency, duplication, and potential significant adverse impacts. The requirement for an extremely involved monitoring program would be costly and difficult for the Government to administer.

As with alternative 1, the environmental impacts of the various exploration methods contained in alternative 3 are generally applicable to this alternative. However, there will be no assurance other than that provided in the applicant's approved plan, and the controls imposed by monitoring, that significant adverse impacts will not occur. While onsite monitoring may prevent many impacts from occurring, it does not provide the fail-safe of detailed regulatory guidance from which plans can be developed and evaluated. For example, the proposed regulations delineate special use areas to protect other wildlife in addition to caribou. No such areas would be defined by regulation if this alternative is selected. Therefore, disturbances to fish and wildlife, sensitive land cover types and archeological resources are likely to occur without the guidance on restricted entry, adequate protective cover, use of explosives, harrassment, and so forth. Also, because more plans (and, therefore, more exploratory activities) will likely be approved, this greater activity will probably result in increased cummulative impacts, which together may constitute a significant adverse impact.

ALTERNATIVE 3. REGULATIONS AS PROPOSED (PROPOSED ACTION)

The regulations for oil and gas exploration, appendix A, are designed to prevent any significant adverse effects from exploratory activities. The impacts discussed below are those that could potentially occur as a result of exploratory activities. Of particular concern on ANWR are impacts on soils, vegetation, and water (habitat), on fish and wildlife species, and on the culture and lifestyle of the Inupiat Natives. Specific references to the proposed regulations are provided as appropriate.

Visual impact, and subsequent degradation of the wilderness character of the area may be the greatest potential impact to the ANWR's coastal plain as a consequence of oil and gas exploration activities. The following discussion undertakes to describe, rate, and categorize visual impacts potentially associated with winter and summer seismic operations. Visual impacts described here are based primarily on observations of seismic lines and off-road vehicle operations at Prudhoe Bay (D. A. Walker and others, 1977, 1978) and Lonely (Abele and others, 1978) and in National Petroleum Reserve-Alaska (Everett, 1981a; Reynolds, 1981). Predicted impacts to soils, landforms, and vegetation are used in the evaluation of estimated visual impact at the ends of one and five growing seasons and are summarized in table IV-1. This table provides a basis for determining and evaluating potential visual impacts for winter and summer seismic operations.

The four-point rating scale for estimates of visual impacts is based on the following criteria:

- No visual impact (0) assumes no detectable changes in plant composition or alteration of soil or landforms either on the ground or from the air.

- Slight visual impact (1) assumes that there are some detectable changes to the composition or structure of the vegetation, soils, or landform. These are of minor, nonextensive nature.

Table IV-1.--Provisional visual impact matrix for seismic surveys within the Arctic National Wildlife Refuge, Alaska

(Note: Impacts are rated for summer (S) and winter (W) operations. Fractions denote visual impact after one summer (numerators) and after five summers (denominators). Ratings: 0 = no visual impact; 1 = slight visual impact; 2 = moderate visual impact; 3 = severe visual impact. Columns 1 through 8 are impacts related chiefly to soils and landforms; columns 7 through 11 are related chiefly to vegetation)

Landcover Categories	1. Compression of organic mat		2. Shearing of surface mat		3. Destruction of surface pattern or soil profile		4. Hydraulic erosion including siltation		5. Thermal erosion		6. Spontaneous liquifaction (mass movement)		7. Processed hydrocarbon spills		8. Sewage		9. Breakage of vegetative parts		10. Compression of erect dead plant material		11. Displacement of tussocks and/or mosses	
	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W
I Water	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	1/0	1/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
IIa. Pond Complex	3/2	1/0	3/2	1/1	1/1	0/0	0/0	0/0	1/3	0/0	0/0	0/0	1/1	1/1	2/1	1/1	2/2	0/0	2/1	0/0	2/2	0/0
IIb. Aquatic Tundra	1/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	1/1	1/1	1/0	1/0	0/0	0/0	0/0	0/0	0/0	0/0
IIIa. Wet Sedge Tundra (non-complex)	2/1	0/0	1/0	0/0	0/0	0/0	0/0	0/0	1/3	0/0	0/0	0/0	1/1	1/1	2/1	1/0	2/0	1/0	3/0	1/0	3/2	1/1
IIIb. Wet Sedge Tundra (very wet complexes)	3/2	1/0	3/2	1/1	1/1	0/0	0/0	0/0	1/3	0/0	0/0	0/0	1/1	1/1	2/1	1/0	2/0	1/0	3/0	1/0	3/2	2/2
IIIc. Wet Sedge Tundra (moist complexes)	2/1	0/0	2/1	1/0	1/1	0/0	0/0	0/0	1/3	0/0	0/0	0/0	1/1	1/1	2/1	1/0	2/0	1/0	2/0	1/0	2/0	1/1
IIId. Wet Sedge Tundra (saline)	1/1	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	1/1	1/1	0/0	0/0	1/0	0/0	0/0	0/0	0/0	0/0
IVa. Moist/Wet Sedge Tundra Complex	2/1	0/0	1/0	0/0	1/1	0/0	0/0	0/0	1/3	0/0	0/0	0/0	2/1	1/1	2/1	1/0	2/0	1/0	3/0	1/0	3/2	2/2
IVb. Dry Prostrate Shrub-Forb Tundra (Oryas River Terraces)	1/0	0/0	3/2	2/2	2/2	1/1	0/0	0/0	0/0	0/0	0/0	0/0	3/2	3/2	1/0	1/0	2/1	2/1	1/0	1/0	1/1	1/1
Va. Moist Sedge-Prostrate Shrub Tundra	2/1	1/0	1/0	0/0	1/1	0/0	1/2	0/0	1/2	0/0	0/0	0/0	3/2	3/2	1/0	1/0	2/1	1/0	2/0	1/0	2/1	1/0
Vb. Moist Sedge/Barren Tundra Complex (Frost boil Complex)	2/2	1/0	1/0	0/0	2/2	1/0	0/0	0/0	1/2	0/0	0/0	0/0	3/2	3/2	1/1	1/0	2/1	1/0	2/0	1/0	2/1	1/0
VI Moist Tussock Sedge-Dwarf Shrub Tundra	2/2	1/0	2/1	1/0	1/0	0/0	1/2	0/0	1/3	0/0	0/0	0/0	2/1	2/1	1/1	1/0	2/2	2/1	2/0	1/0	2/2	2/1
VIIa. Moist Dwarf Shrub-Tussock Sedge Tundra (uplands)	2/2	1/0	2/1	1/0	1/0	0/0	1/2	0/0	1/3	0/0	0/0	0/0	2/1	2/1	1/1	1/0	3/2	2/1	2/0	1/0	3/2	2/1
VIIb. Moist Dwarf Shrub-Tussock Sedge Tundra (birch tundra)	2/2	1/0	2/1	1/0	1/0	0/0	1/2	0/0	1/3	0/0	0/0	0/0	3/2	3/2	1/1	1/0	3/2	2/1	2/0	1/0	2/1	1/0
VIIc. Moist Tussock Sedge-Dwarf Shrub/ Wet Dwarf Shrub Complex (water track complex)	2/2	1/0	2/1	1/0	1/0	0/0	2/2	0/0	1/3	0/0	0/0	0/0	2/1	2/1	1/1	1/0	3/2	2/1	2/0	1/0	3/2	2/1
VIII Shrub Tundra	1/0	0/0	1/1	0/0	1/0	0/0	2/3	1/2	0/0	0/0	3/3	0/0	2/1	2/1	1/0	1/0	3/2	3/2	2/1	2/1	1/0	0/0
IXa. Partially vegetated - River bars	0/0	0/0	1/0	1/0	1/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	2/0	0/0	0/0	0/0	1/0	0/0	0/0	0/0	0/0	0/0
IXb. Partially vegetated - Alpine tundra	1/0	0/0	1/0	0/0	1/0	0/0	1/2	0/0	0/0	0/0	0/0	0/0	2/1	2/1	1/1	1/0	2/1	1/0	2/0	1/0	2/1	1/0
IXc. Partially vegetated - Sorted stone nets	0/0	0/0	0/0	0/0	2/2	1/1	0/0	0/0	0/0	0/0	0/0	0/0	1/1	1/1	0/0	0/0	1/1	0/0	0/0	0/0	0/0	0/0
IXd. Partially vegetated - Beaches	0/0	0/0	0/0	0/0	1/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	2/0	2/0	0/0	0/0	1/0	0/0	0/0	0/0	0/0	0/0
IXe. Partially vegetated - Sand dunes	0/0	0/0	0/0	0/0	3/2	2/1	0/0	0/0	0/0	0/0	0/0	0/0	2/0	2/0	0/0	0/0	2/1	0/0	0/0	0/0	0/0	0/0
X Barren gravels or rock	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
XI Barren mud or wet gravel	1/0	0/0	0/0	0/0	1/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
XII Ice	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	1/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0

- o Moderate visual impact (2) assumes that alterations of the geobotanical aspects of the terrain are more severe than with a (1) rating but that in most cases the original vegetation, soil, and landforms can still be discerned.

- o Substantial visual impact (3) assumes that in some areas the vegetation, soils, and/or landforms will be completely altered. These may be of a local nature, such as in areas of diesel spills or where thermokarst pits have formed.

Various impact categories contribute to the overall visual impact of vehicle trails. Several of the more important ones are listed below with short explanation.

- o Compression of the organic mat.--This refers to the nonelastic compression of the organic vascular and moss vegetation mat.

- o Shearing of surface mat.--This may result in the exposure of mineral soils or lower organic layers and often results in increased thaw, which, in turn, could lead to thermokarst.

- o Destruction of surface pattern or soil profile.--This results in changes in soil profiles, such as the elimination of a thin organic horizon or the A horizon, and/or alteration of microscale features, such as flattening of hummocks, polygon rims, or frost boils.

- o Hydraulic erosion.--This is caused by flowing water and soil erosion. Vehicle tracks on the slopes are often channels of erosion. Siltation of streams and lakes are often related to this factor.

- o Thermal erosion.--This is often caused by a decrease in the surface albedo (reflectivity) due to such factors as removal of the vegetation mat, flattening of the erect dead vegetation, or ponding of water, which leads to increased thaw of the permafrost table and subsidence of soil surface.

- o Spontaneous liquifaction.--This is the mass movement of saturated soils on steeper slopes. It can be triggered by mechanical vibrations.

- o Processed hydrocarbons.--This refers to diesel and gasoline. If spills should occur, damage could be locally severe. Clean up is generally feasible from snow or ice surfaces; thus, impacts from accidental spills are expected to be less severe in the winter than with similar spills during the summer.

- o Sewage.--Impacts from sewage disposal should be minimal if it is incinerated, treated, or backhauled. The proposed regulations provide that gray or wastewater may be discharged to the surface provided it is filtered, disinfected, and not discharged directly into lakes or rivers.

- o Breakage of vegetative parts.--Damage to plants will be most severe in areas with woody vegetation.

- o Compression of erect dead plant material.--Upright dead components of the vegetation cover, mainly dead herbaceous leaves and stems, have high reflectivity to solar radiation. Vehicles tend to compress this component to the soil surface, causing a darker vehicle track with decreased albedo, leading eventually to increased thaw and a deepening of the vehicle track. The "greening" of vehicle trails is in part due to this effect, plus the added nutrients that are released with most tundra disturbances.

- o Displacement of tussocks and/or mosses.--Overturning and displacement of vegetation can occur adjacent to vehicle tracks, resulting in some places in piles of material and the smothering of cover plants.

- o Thermokarst.--Water-filled sinks, cave-ins, and other small depressions caused by local melting of permafrost.

Predicting specific geographic locations where impacts are likely to be the greatest would be possible only with accurate maps depicting slope aspect, landform types, and vegetation. Also, snow cover patterns play an important part in impact prediction. This can only be done on a seasonal, on-site basis, after snow patterns develop.

The potential damage to the wilderness character of the study area is an important consideration of the exploration program. Some impacts which may be acceptable in terms of fish and wildlife habitat loss or temporary species population-level declines could be unacceptable in lieu of wilderness values and characteristics necessary for the area to remain qualified for wilderness designation. Section 1004 of ANILCA requires that wilderness study areas, including the ANWR coastal plain, are to be administered to maintain existing wilderness character and potential for inclusion in the National Wilderness Preservation System, until determined otherwise by Congress. Since Section 1002 prohibits exploration activities resulting in significant adverse effects on the ANWR fish and wildlife, their habitats, or the environment, that standard applies to the protection of wilderness values. The regulations (appendix A) which are proposed for oil and gas exploration on the ANWR contain environmental safeguards to prevent or minimize permanent visual impacts. These safeguards address various facets of environmental protection, including the terrestrial, aquatic, and human environments, special use areas, and other general environmental considerations. The Regional Director, U.S. Fish and Wildlife Service (FWS), may also impose terms and conditions in the special use permit to provide any further protection considered appropriate.

The following discussions of exploratory methods and techniques identify those potential adverse impacts that may occur with each and describe applicable provisions of the proposed regulations which ensure the prevention of significant adverse impacts.

Winter Seismic Exploration by Ground Vehicle

Winter seismic surveys most commonly conducted on the arctic coast at the present time utilize heavy ground vehicles equipped with tracks or wheels. Towed equipment is drawn on either tracks or sleigh-type runners. The following paragraphs identify the potential effects of these vehicles on the physical, biological, and human environments. The relative damage/disturbance of each of the three winter seismic techniques are compared where differences are distinct; in many instances, impacts would be expected to be virtually identical.

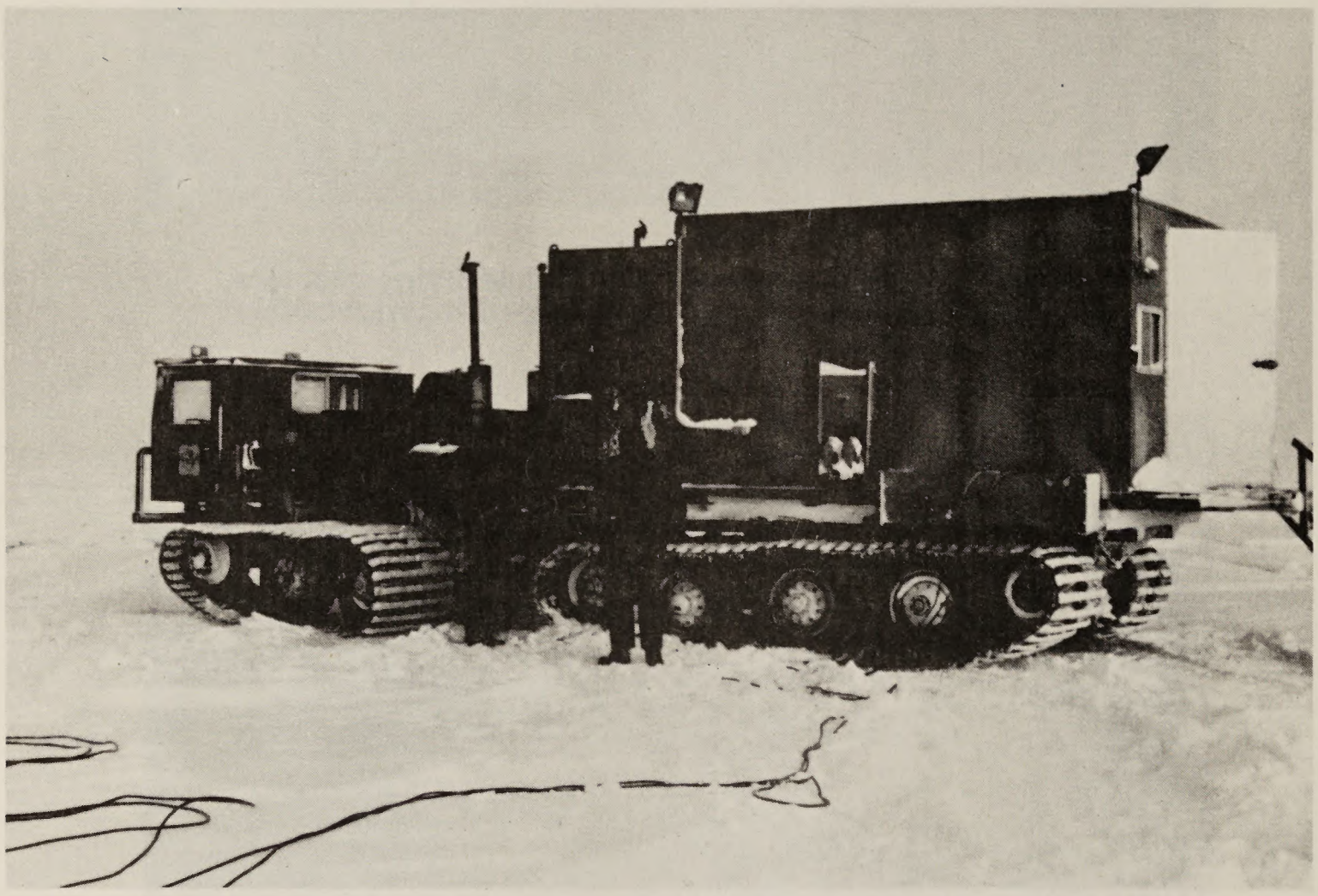
Sometimes in November, but more commonly in December, ground and water surfaces become sufficiently frozen and snow cover becomes adequate to support

Microrelief obliterated by windblown, drifted snow.

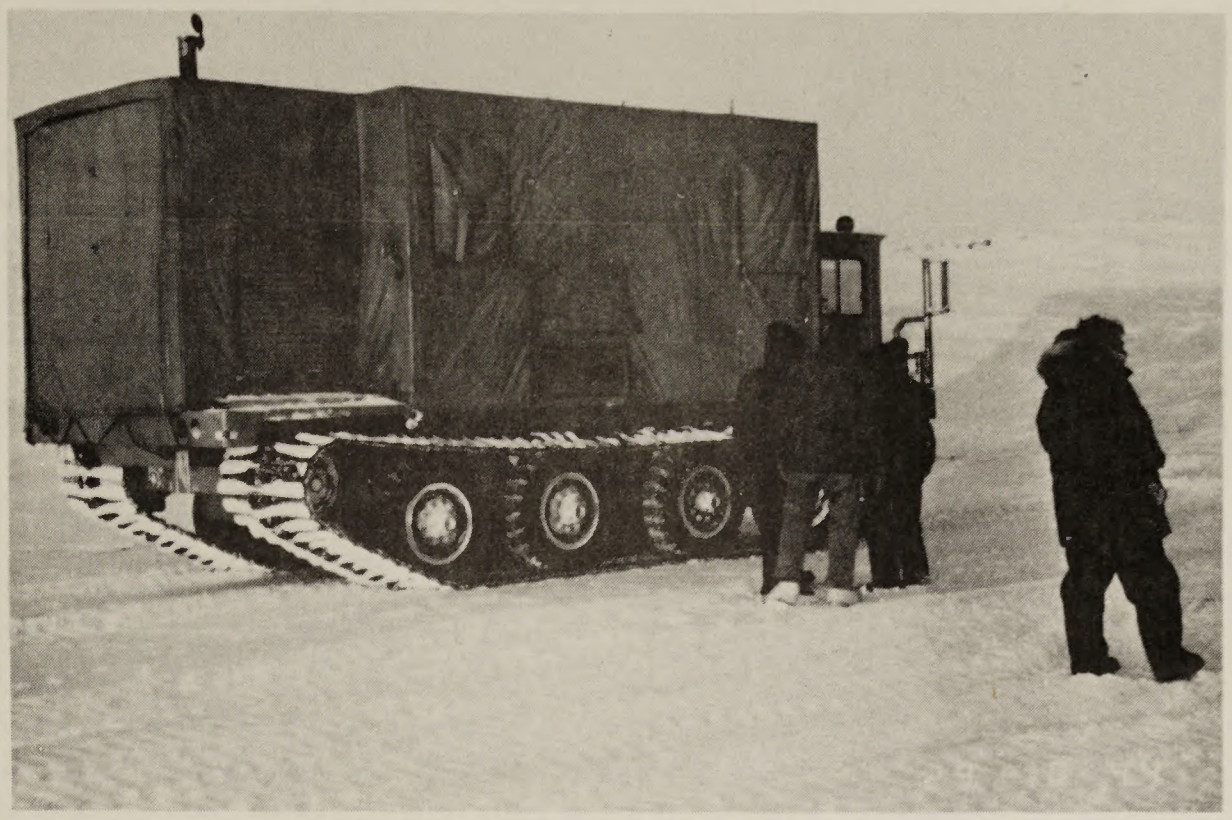
Living modules, kept close and parallel for crew safety during whiteouts. Photographs, taken on State lands just east of the Colville River Delta, by D. McGillivary, U.S. Fish and Wildlife Service, February 1982.

Skid-mounted, tractor-drawn camp module living quarters.

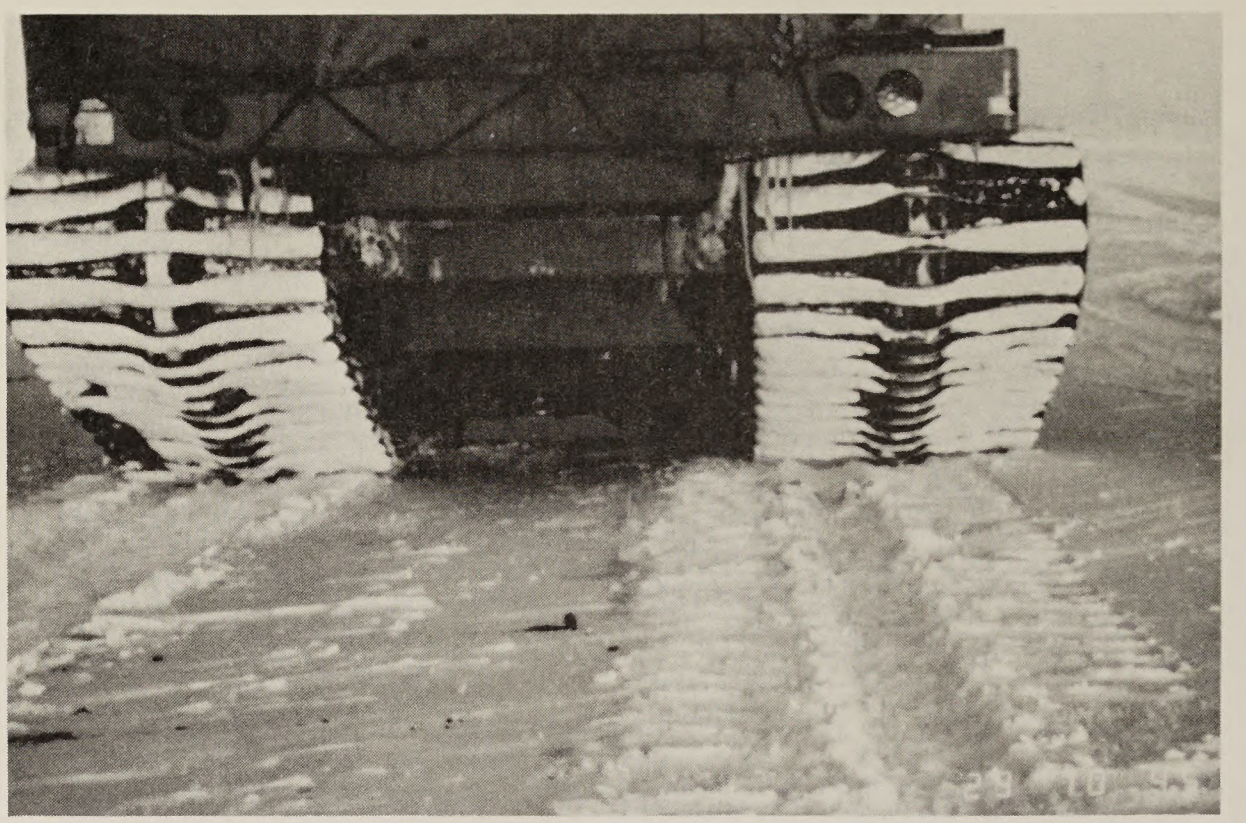
Survey crew at work, with geophone lines stretching into distance. Photographs, taken on State lands just east of the Colville River Delta, by M. P. Wennekens, U.S. Fish and Wildlife Service, January 1982.



Recording truck for Vibroseis equipment. Photograph, taken on State lands just east of the Colville River Delta, by D. McGillivary, U.S. Fish and Wildlife Service, February 1982.



Vibroseis equipment. Photographs, taken on State lands just east of the Colville River Delta, by M. P. Wennekens, U.S. Fish and Wildlife Service, February 1982.



Imprints of Vibroseis plate and tracks. Photographs, taken on State lands just east of the Colville River Delta, by M. P. Wennekens, U.S. Fish and Wildlife Service, January 1982.

the heavy ground vehicles required to provide transportation, housing, and equipment support for this type of winter seismic exploration. The proposed regulations require that use of ground vehicles in winter be restricted to areas where frostline and by snow cover are sufficient to avoid significant damage or displacement of the vegetative mat or soil. Winter ground operations require considerable logistical support by fixed-wing aircraft. Detailed descriptions of the ground vehicles and aircraft used in a typical winter operation are defined by the proposed regulations. Operations normally continue throughout the winter, and the ground equipment is moved to parking areas for summer storage prior to thawing and breakup, which normally begin in mid-May.

Physical Environment

Geology

Ice-rich permafrost underlies most of the vegetative mat on the coastal plain active layer. Should destruction or removal of vegetation occur, such as by blading or plowing, it could result in thawing of permafrost. The resulting loss of strength and volume could cause differential settlement or liquefaction of soils. Such effects are often long term, irreversible, and, in some cases, self-perpetuating. In addition, permafrost degradation can lead to severe problems of slope stability and erosion. On sloping terrain, erosion usually occurs as runoff and concentrates in depressions formed by differential settlement. Operating cat-trains on slopes, or where sufficient snow depth does not occur, greatly increases the chance of vegetation and soils disturbance as a result of spinning wheels, slipping tracks, or compaction. Also, blading or plowing deep snow with bulldozers greatly increases risks of surface disturbance. Areas most likely to be damaged by ground vehicles are stream terraces, coastal bluffs, lake embankments, windblown ridges, and other uneven or steep terrain where vehicles may encounter problems with traction or where the snow cover is either thin or so deep as to require plowing. Vegetative mat is highly sensitive to disturbance by tracked or wheeled vehicles following winter breakup, when it may thaw to a depth of 1 foot or more during the summer months.

The proposed regulations require that vehicles be operated in a manner which will prevent significant adverse impact to the vegetative mat. They specify that ground vehicles operate only in winter when protective cover is adequate; required blading of snow is minimal; use of explosives will not damage the surface; campsites are restricted to durable ground; banks of streams, rivers, or lakes will not be damaged by use of low-angle approaches or snow bridges; and disturbed-surface areas will be rehabilitated.

Water Resources

Water use by a typical 50-person seismographic crew is about 500 gallons per day. A common source for this water is lakes that do not freeze to the bottom; however, few lakes of this depth occur in the ANWR study area. Where water is not readily available from springs or lakes, the cat-trains are equipped with mechanical snow melters which provide water for all camp needs except human consumption. The proposed regulations prevent water withdrawal from any stream, lake, river, or subsurface source without approval of the Regional Director. Additionally, no removal or compaction of snow is to occur on river pools, no ground vehicles will be allowed to cross active spring areas, and only limited exploratory activities, as specified by the Regional Director, will be allowed

Garbage burning (solid-waste disposal).

Ice road between Kaparuk Field and the Colville River Delta. Photographs by M. P. Wennekens, U.S. Fish and Wildlife Service, January 1982.

Drilling for water through lake ice.

Filling water tanks. Photographs, taken on State lands just east of the Colville River Delta, by D. McGillivary, U.S. Fish and Wildlife Service, February 1982.

throughout the year in the Sadlerochit Spring special area the boundaries of which will be determined by the Regional Director.

Discharge of wastewater onto the tundra surface may result in local soil enrichment, which, in turn, can cause more vigorous plant growth. Such response results in small green spots in the tundra which fade into the background in a few years as the nutrients become exhausted. The only liquid waste permitted to be discharged would be filtered disinfected gray water. Discharge into lakes and streams is prohibited by the regulations. Overall, the use and discharge of water would be of minor, local effect and short duration on the ANWR study area.

Oil or fuel accidentally spilled on ice or snow would be much more readily sighted and easily cleaned up than it would be on thawed ground or open-water surfaces. With proper preventive care and contingency cleanup procedures, little if any residual oil would contaminate the water following breakup. The proposed regulations require that all hazardous substances be contained, controlled, and cleaned up in accordance with an approved contingency plan containing provisions that any spills or leakage of such substances be reported immediately or as soon as communication can be established, that no fuel storage facilities be located within the annual flood plain of fish-bearing watercourses or within 100 feet of any other water body, that no vehicles be refueled within such areas, and that fuel storage sites be approved by the Regional Director. All fuel containers are to be capped when not in use.

Air Quality

The most common air pollutant resulting from seismic exploration on ANWR would be local combustion emissions from motorized vehicles and equipment. Combustion emissions are composed of hydrocarbons, nitrous oxides, photochemical oxidants, sulfur dioxide, carbon dioxide, carbon monoxide, and water.

The emission of water vapor and hydrocarbons can produce local ice fog under arctic temperature conditions. The extent and duration of ice fog would depend on the quantity of emissions and on wind conditions. It is not expected that emission concentrations or ice fog would ever reach levels that pose an environmental hazard or cause any significant degradations in air quality. The impacts of winter seismic explorations on the air quality of the ANWR should be negligible.

Biological Environment

Vegetation and Soils

Winter traffic can be expected to cause significantly less damage to vegetation and soils than summer traffic, although the potential for significant impacts still exists. Reynolds (1981) studied the effects of different vehicle types traveling across four arctic vegetation types during the winter. Little damage occurred to all types of vegetation from a single pass of low-pressure vehicles traveling along seismic lines. More impact resulted after passage of tractors pulling sled-mounted camps (cat-trains). Natural recovery of disturbed areas occurred within 16 months, although complete recovery of sedge tussocks and riparian willow stands disturbed by tractor trains had not occurred after 28 months. Recovery of the willows was expected to take several years. With seismic activity, multiple vehicle passes can be expected. The proposed regulations require that

Track scarring and torn terrain, exposing tops of vegetation, as a result of too thin a snow cover. Photographs, taken on State lands just east of the Colville River, by M. P. Wennekens, U.S. Fish and Wildlife Service, February 1982.

Track scars on upslope terrain.

Terrain torn as a result of too sharp a turn. Photographs, taken on State lands just east of the Colville River Delta, by M. P. Wennekens, U.S. Fish and Wildlife Service, February 1982.

movement of equipment through riverine willow stands be avoided unless approved by the Regional Director. Ground vehicles must be of a type causing the least practicable harm to the surface, and are to be operated only in winter where there is adequate protective cover. Vehicle operations are to cease in spring when the Regional Director determines that protective cover is no longer adequate.

As discussed above, snow cover and frost depth provide protection for the vegetation and are important parameters in determining impacts of surface travel. In a report which reassesses winter precipitation data on Alaska's North Slope, Benson (1981) concluded that Barter Island receives more snow than Barrow, but that there is a zone of reduced precipitation near the Jago River. Wind measurement data comparisons between Barrow and Barter Island show that winds which are most important in transporting snow occur about 9 percent more frequently at Barter Island than at Barrow (Benson, 1981). Owing to a greater diversity of topographic features and a greater frequency of strong winds, snow cover tends to be more variable in the ANWR study area than on most of the coastal plain to the west. In general, snow accumulates in the numerous drainages and other depressions in the study area (Benson, 1981), often leaving ridges and elevated land surfaces exposed or with only a thin covering of snow in certain areas (Everett, 1981a).

If disturbance occurs, the ultimate impacts on vegetation and surface stability will vary. If the vegetation is completely removed, thermokarst erosion can lead to depressions and gullies which may not recover for many decades. Aggravated erosion can occur along coastlines, lakeshores, and riverbanks and on slopes. Moderate disturbance of vegetation can cause localized slumping, boggy depressions, increased frost heaving and crack formation. Tussocks may be destroyed and polygon ridges broken. Drainage patterns may be altered. Even minimal disturbance can cause minor tussock damage, brown trails, or green trails, which degrade esthetic and wilderness values (Baseline Study, U.S. Fish and Wildlife Service, 1982). The proposed regulations restrict the use of surface vehicles and special use permits will contain any required additional terms and conditions necessary to protect the surface.

One indirect impact of vehicle use may occur if snow removal is necessary to facilitate movement or siting of equipment. Blading snow by caterpillar tractors reduces its insulative value and--where the ground is uneven (for example, tussocks or polygon ridges) or blading is too deep--may result in removal of organic material. If the active soil layer is removed or deeply scarred, the impacts will be more severe and long term. The proposed regulations restrict snow blading to the minimum necessary. Should damage occur, the regulations require rehabilitation of disturbed areas in accordance with schedules and plans approved by the Regional Director.

Following is a discussion of the five regionally significant terrain types and their relative sensitivity to vehicular traffic.

Flat Thaw-Lake Plains

Coastal plain topography with large thaw-lakes, drained lake basins, and expanses of low-centered ice-wedge polygons is found in only 3 percent of the ANWR study area. However, this landform provides particularly valuable waterbird habitat. Special use permit terms and conditions will ensure that care is taken to avoid abraiding polygon ridges which may protrude through the snow.

Hilly Coastal Plain

This landform type is a complex region of very gently undulating tussock tundra, thaw-lake plains, and pond complexes stretching inland between the Hulahula and Jago Rivers from the flat thaw-lake plain to the foothills. Possible impacts to this habitat would be a combination of those possible in the thaw-lake plain plus those associated with the foothills, e.g., crushing tussocks. Reynolds (1981) found that impacts resulting from tractor trains were greater in tussocks than in wet sedge meadows or dry uplands and that recovery took longer.

Drier areas within the tundra are few and often of special interest as wildlife habitat. For example, dunes, pingos, and the margins of many small tundra streams, as well as river terraces, are relatively dry areas where dens of foxes, lemmings, and ground squirrels are concentrated. Brown bears hunt lemmings and ground squirrels in these dry sites. Caribou find relief from mosquitoes in dunes and elevated sites near the coast. Birds such as snowy owls, jaegers, and gulls use these high vantage points for observation posts; and numerous others use them for breeding grounds. These areas are also botanically important. Pingos often act as dry islands in a sea of wet tundra and contain numerous unique plant communities similar to those found in high alpine areas (Murray, 1979; D. A. Walker, 1981). Special use permit terms and conditions will ensure that pingos are avoided by surface vehicles.

Foothills

Impacts to foothills vegetation may vary considerably, depending mostly on the steepness of the terrain, and the amount of ground ice and snow cover. Areas where solifluction forms (discontinuous stripes of frost scars or lobes) are common and, where slope breaks exceed 7-10 percent, are highly susceptible to vehicular impacts because of the relatively great microrelief and high moisture content. Because of the exposed nature of inter-water-track areas, snow cover can be thin or absent, and disturbance to vegetation could be severe. The proposed regulations require that vehicles be operated in a manner that prevents significant damage to the vegetative mat or soil. Ground vehicles must be of types causing the least practicable harm to the surface and must be operated only in winter when and where there is adequate protective cover. Vehicle operations will cease in spring when the Regional Director determines that the protective cover is no longer adequate. Rehabilitation of disturbed surface areas by the permittee must be done in accordance with schedules and plans approved by the Regional Director, and vegetation be replaced exclusively with endemic species.

Alpine Tundra

Damage to the few small alpine areas is unlikely to occur because they are inaccessibe to ground vehicles.

River Flood Plains

Unvegetated islands of gravel, gravelly sand, or silt (in the deltas) are probably inundated at least sporadically in most years. Vehicular impacts to these areas are expected to be minor because of the natural reworking that occurs.

Partially vegetated islands and bars are among the most floristically rich sites in the region. Willows are common on partially vegetated areas and may form

fairly extensive thickets which are important habitat areas for mammals and birds. Destruction of a significant amount of this limited supply of riverine willows would negatively impact several wildlife species. Willow areas potentially affected by vehicles are relatively small since crossings will consist of single trails at intermittent intervals. Recovery of damaged willows would probably occur in several years. Outright destruction of significant willow habitat is highly unlikely. As specified in the proposed regulations, the movement of equipment through riverine willow stands will be avoided unless approved by the Regional Director, rehabilitation of disturbed areas is to be accomplished in accordance with schedules and plans approved by the Regional Director, and vegetation is to be replaced exclusively with endemic species.

Fish and Wildlife Populations and Behavior

Caribou

Winter surface seismic work in the ANWR will have minimal direct impact on the Porcupine Caribou Herd, inasmuch as these animals normally depart from the area by mid-July and do not return until early May, just ahead of breakup. On the other hand, winter operations will come in direct contact with segments of the Central Arctic Caribou Herd, which are present in portions of the ANWR coastal plain thoughout the winter.

Although wintering caribou can be found nearly anywhere in the study area, overall density is low. Because seismic and associated air support operations are isolated and transient, only scattered, local disturbances of short duration are expected to occur. Studies of winter seismic activities in the Canadian Arctic indicate that caribou reactions to such activities are variable. In a study on Banks Island, Russell (1977) reported that all caribou groups encountered by seismic vehicles at less than 0.8 km reacted by moving (usually walking) away at right angles. At distances greater than 1.2 km, Russell (1977) found that caribou remained in the area and generally showed no reaction to the activity. Urquhart (1973) found that the distance at which caribou would react to seismic crews varied according to terrain. In rolling country seismic crews were able to get nearer to caribou than on flat areas. However, the intensity of reaction in rolling terrain was greater, possibly due to the "surprise" of a moving object suddenly appearing over a rise (Urquhart, 1973, in Carruthers, 1976). Russell (1977) reported that caribou reoccupied habitat within 0.8 km of a seismic line within 2 to 4 days after the disturbance ceased. In a study of seismic activities near wintering groups of the Porcupine Herd on the northeastern slope of the Richardson Mountains, Hoffman (1974) reported that a group of caribou was displaced from selected range and that seismic crew disturbance apparently stimulated an early spring migration.

Numerous studies and observations have been made with respect to caribou encounters with obstructions (Klein, 1980). Movement of wintering caribou in the study area may be impeded to some degree by vehicle tracks along seismic lines. Urquhart (1973) found that caribou encountering vehicle snow trails along seismic lines would often turn and move parallel to the line. No effect on caribou migration movements was observed. The barrier effect created by bulldozed lines was greater than on lines where there was no bulldozing (Urquhart, 1973). Old, drifted-in trails along seismic lines seem to present a lesser barrier than new lines (Urquhart, 1973). Wintering caribou tend to shift about in response to weather (especially storms), snow conditions, and disturbances from predators and humans. Although the precise consequences of impairment of the caribou's natural

movements by seismic lines in the study area are not known, based on observations in other areas, it is not expected to be significant.

Because of the relatively insignificant quantity of vegetative resources that would be lost under a properly managed winter seismic program, no significant impact to caribou forage is expected to occur.

To avoid significant adverse impacts to caribou, the proposed regulations require that wildlife not be harassed, and exploratory activities be conducted so as not to impede or restrict the free passage or movement of animals.

Muskoxen

Muskoxen have a strong fidelity for a limited home range, commonly no more than 100 square kilometers. Willows are a preferred food, although sedges and forbs make up some of their diet. Since this preferred food is primarily associated with riparian habitats, muskoxen distribution is limited to the major drainages of the study area. Their food habits, as well as physical, physiological, and behavioral characteristics make muskoxen particularly susceptible to disturbance, especially if it causes them to run or leave a preferred feeding area for any length of time. The animals are not physically equipped for running or any other exertion which may cause overheating. Their heavy wool coats do not permit their bodies to quickly return to normal temperature once they have been elevated due to abnormal physical exertion. Also, because of the limited quantity of preferred food plants in their limited winter range, any prolonged absence from these areas could have adverse affects, particularly on pregnant cows or individuals in poor condition. Winter seismic surface activities would probably have minimal impact on muskoxen if care is taken to avoid direct contact, to route surface vehicles and aircraft around herds, and to avoid camping or working for prolonged periods within an area occupied by muskoxen. Because they band together in large groups, it is unlikely that muskoxen avoidance would be difficult. Of greater concern is the possibility of aircraft harrassment. The herds are easily visible for many miles because of the contrast of their dark coats to the white surface background; therefore, they pose a constant temptation to aircraft pilots and passengers for "a closer look" or for photography.

Muskoxen are protected by proposed regulations with the same restrictions described above under "Caribou" except that no explosives are to be detonated within one-half mile of any muskoxen herd. Special use permit terms and conditions will also be tailored to ensure that concentrations of muskoxen are avoided.

Polar Bears

Some female polar bears may establish maternity dens in the ANWR study area during the winter. Response to disturbance varies. On one occasion several bears were known to have deserted newly formed dens in October and November due to the presence of scientific investigators, and the impact was believed to be significant (Belikov, 1976). Sows with cubs emerge from dens in March and April, vulnerable to disturbance because of the small size of the cubs and the weakened condition of the sows. Human disturbance was believed to have been the reason for a female and extremely small cub having left a den in early March (Lentfer, 1974b). On another occasion, disturbance to a family group of one female with two cubs by a seismic explosion caused the group to leave their den prematurely (Moore

and Quimby, 1974). On the other hand, Belikov (1976) reported having closely observed females with cubs in dens without apparent disturbance, and a female with two cubs at a den in Prudhoe Bay was observed by oil company personnel for several weeks without apparent disturbance (Lentfer, 1974a).

The impacts of disturbance to denning female polar bears may be twofold. If the pregnant female is disturbed while searching for a den, she may retreat to the pack ice, where suitable denning sites may be scarce. Denning success and productivity of such females could be reduced. Disturbing females with cubs could cause neglect or abandonment of cubs, leading to their death and therefore a lower recruitment to the population (Lentfer and Hensel, 1980).

Preserving undisturbed denning habitat on shore may be important for polar bears. Although the number of bears returning each year varies according to ice, snow, and weather conditions, they are believed to show fidelity to birth sites and try to reach the area previously used for denning (Lentfer and Hensel, 1980). Denning habitats include areas which accumulate drifting snow, such as rivers, lakebanks and coastal bluffs. These drifted areas could be rendered undesirable as a result of human activity and machine use. To avoid significant adverse impacts to polar bears, the proposed regulations prohibit harrassment, require that exploratory activities not impede or restrict the free passage or movement of wildlife, prohibit detonation of explosives within one-half mile of known bear denning sites, and allow only limited exploratory activities November 1 to April 15 in polar bear denning special areas designated by the Regional Director.

Another potential impact to polar bears is attraction to waste disposal sites or camps, where they can become nuisances or a danger to personnel (Lentfer and Hensel, 1980; Woolridge and Belton, 1980). Nuisance bears are usually relocated or destroyed. The proposed regulations prohibit feeding wild animals, and leaving garbage or edibles where they may attract wild animals, and require that garbage be kept in animal-proof containers prior to incineration.

Other Mammals

Impacts that could occur to wolves include problems associated with their attraction to garbage associated with camps (Grace, 1976), as well as disturbance at den sites and during the rearing season (Chapman, 1977). Foxes attracted to camps could constitute a health hazard due to rabies. Displacement of overwintering caribou of the Central Arctic Herd would result in comparable changes in the distribution of wolves, foxes, and wolverines. These changes would be temporary and insignificant.

A detrimental situation could develop if brown bears were disturbed while denning. Reynolds and others (1982) found denning brown bears did not desert dens located within a mile of seismic lines. However, if disturbance were great enough to cause den abandonment, it could result in poor physical condition of adults and increase the vulnerability of young bears. Few brown bears are believed to den on the coastal plain, thus impacts from winter seismic activity should be minor.

Since there are few moose in the study area during the winter, the effects of encounters with these animals would be minor. Dall sheep, which would likely be encountered only in the vicinity of Sadlerochit Spring would be protected because the proposed regulations permit only limited exploratory activites in the Sadlerochit Spring special area.

Birds

Few birds are present in the ANWR study area during winter. Consequently, winter seismic operations would affect only a few species. Winter seismic operations should have little effect on raptors, dippers, ravens, snowy owls, and ptarmigan.

Fish

Several characteristics of Arctic fish populations make them highly sensitive to disturbance. They exhibit slow growth, poor recruitment, and late maturity. High concentrations of some species during spawning and in overwintering areas make them especially vulnerable. Explosives will not be used in open water, and it is not likely that either the air-shot or conventional subsurface explosion technique would have any effect on fish. The proposed regulations require that no explosives be detonated closer than one eighth of a mile from any river, stream, spring or lake identified by the Regional Director to support fish populations or fish eggs, except that during winter explosives may be utilized on lakes or rivers which are frozen to the bottom (bottom sediments must also be frozen) provided that such use of explosives is approved in advance. There is no evidence that the mechanical Vibroseis technique is harmful to fish.

During winter, sources of water are scarce on the ANWR. There are few tundra lakes, and they are generally of poor quality and either must be treated to be potable or are so shallow that they freeze solid (Schallock, 1976). Although little water would be required for the exploration program, any withdrawal from overwintering pools or springs could have significant effects on fish. In instances where this could occur, the proposed regulations require seismic crews to melt snow for the bulk of their water needs.

Another potential impact to overwintering fish populations is the thickening of the ice which occurs with removal or compacting of the insulating snow cover. Clearing or compaction of snow over lakes or river pools can cause freeze-down and fish mortality. Lakes are not common in the study area and the locations of proposed airstrips would be evaluated during review of exploration plans with needed siting and timing considerations addressed through special use permit terms and conditions.

Dissolved oxygen depletion can cause direct mortalities and long-term damage to the food structure of arctic waters (Craig and McCart, 1974; Schallock, 1976). Environmental contamination from sewage wastes and fuel and oil spills are potentially threatening to arctic fish populations. Domestic wastes entering arctic aquatic ecosystems could cause depletion of dissolved oxygen, particularly during the winter when flow is minimal and the assimilative capacity is much reduced.

To avoid significant adverse impact upon fish, the proposed regulations require that water not be removed from any stream, lake, river, or subsurface source without written permission of the Regional Director; explosives not be detonated closer than one-eighth of a mile from any river, stream, spring, or lake identified by the Regional Director to support fish or fish eggs (except that explosives may be used on those lakes or rivers which are frozen to the bottom, including bottom sediment); compaction or removal of snow not be allowed on river pools; operations not be conducted in a manner that will impede fish passage, disrupt spawning areas, or block or change the character or course of, or cause

significant siltation or pollution of, any stream, river, pond, pothole, lake, lagoon, or drainage system; and gray water be filtered, disinfected, and discharged so it does not directly enter lakes and streams.

Threatened and Endangered Species

There are three listed species on or near the coastal plain of the ANWR. The gray whale is extremely rare in the area. The bowhead whale is not present in the Beaufort Sea when winter seismic exploration would occur; thus, there is no possibility of impact. Although arctic peregrine falcons are known to nest in other portions of the ANWR, none has recently been observed nesting in the coastal plain. Peregrines have been sighted hunting and/or migrating eastward along the coast in summer and fall but are not present in the ANWR from October to May; therefore, winter seismic operations should have no effect.

Human Environment

Socioeconomics

The level of sustainable subsistence harvest is tied directly to the abundance of wildlife resources on the refuge. While positive impacts of an exploration program, such as a stimulated local cash economy, could financially benefit local people, any significant loss of wildlife would negatively affect residents dependent on subsistence use of these resources.

With adherence to the proposed regulations, present subsistence uses within the study area should not be significantly affected. An evaluation of the issues raised by local people during the scoping meetings in August 1981 indicated that there is little likelihood of more than temporary disturbance or displacement of subsistence species on the basis of activities that will be allowed. Such disturbances will be minimized by placing appropriate terms and conditions in special use permits necessary to assure that significant adverse effects on the refuge's wildlife and habitat are avoided. These protections will in turn have the effect of protecting subsistence uses and needs by limiting the types, locations, and periods of exploratory activities on refuge lands which are needed for subsistence purposes.

The degree to which the Inupiat culture, social system, and values have remained intact is largely a function of their degree of isolation. This is especially noticeable in Kaktovik, where outside influences have not been as great as in some other areas of the North Slope. The presence of seismic crews would tend to further diminish the sense of isolation, particularly if base camps were established at or near the village of Kaktovik, near Traditional Land Use Inventory Sites or near temporary subsistence camps.

Overall, the impact of winter seismic exploration is expected to have minor, temporary effect on Native culture and life style. There could be some temporary stimulus to local economies, and possibly some short-lived disruption of traditional hunting patterns. Temporary employment opportunities would result for monitoring and guide assistance as well as labor on seismic crews. Subsistence species are not expected to become less abundant, although the presence of seismic crews may temporarily disperse certain animals, thereby influencing the taking of some species.

There would be little difference in impacts on local residents among the three seismic techniques; however, noise associated with an air shot program may be temporarily more disturbing to people within hearing range of the above ground explosions.

Archeology

Only a limited amount of archeological reconnaissance has occurred in the ANWR coastal plain study area. Site-specific surveys are required to determine whether any archeological sites would be affected by exploration.

During the winter, vehicle traffic would not have a significant adverse effect on sites directly encountered because of the snow cover and frozen ground; however, some minor damage could result from crushing, vibration of structural remains, movement of exposed artifact assemblages, or from encountering artifacts by the drilling of shot holes in the case of a conventional seismic operation. Reconnaissance studies are being performed during the summer of 1982 to identify areas which must be avoided by vehicles and personnel.

The proposed regulations authorize the Regional Director to reasonably restrict exploratory activities in areas of known cultural resource sites and areas of predicted high probability of containing cultural resources to minimize or avoid adverse effects. They also require that no vehicle of any type pass over or through known cultural resource sites with standing structures, that no seismic train be allowed to camp on known cultural resource sites, and that no discharge of petroleum or petroleum products be made on the surface of historic or archeological resources. The proposed regulations further permit the Regional Director to require after September 30, 1983, the permittee to identify and evaluate properties eligible for listing on the National Register of Historic Places and to recover data and take other mitigation measures in certain areas prior to any exploratory activities.

Recreation, Wilderness, and Esthetics

There have been no specific studies on the various impacts of exploration activities on the activities of recreationists on the North Slope. Winter seismic activities would have essentially no impact on recreation unless permanent scars or facilities were left in the area. A very limited amount of cross-country skiing may occur in March and April, and skiers would likely be disturbed by vehicles and personnel if they were present in the same area.

Under spedified conditions, temporary intrusions of vehicle trains, helicopter flights, or tent camps should not significantly affect the eligibility of the area for inclusion in the Wilderness System. However, any permanent scars on the landscape could potentially render the ANWR study area ineligible. Natural landmark eligibility at the two nominated sites could also be jeopardized by any permanent damage or permanent evidence of man's activities.

Comparison of Seismic Techniques

Impacts attributable to the mechanical (Vibroseis) and conventional (below-ground explosives) survey methods would be essentially identical. Equipment, vehicles, and numbers of personnel are similar. The major difference is that the conventional method would utilize four to five track-mounted drills, a preloader

Typical daylight, 8 a.m., January 29, 1982.

Typical visibility, 10 a.m., January 29, 1982. Photographs, taken on State lands, by M. P. Wennekens, U.S. Fish and Wildlife Service.

vehicle, and a shooter vehicle in place of the four vibrator units and a vibrator tender. Also, the conventional method would require two to three additional flights per week for resupply of explosives; thus, there would be a slightly greater noise disturbance factor related to aircraft, and a greater chance for fuel spills due to more frequent refueling.

There would be two primary differences utilizing the air-shot survey (Poulter) technique. Vehicles and personnel would not be required to operate vibrator units or drills. Thus, there would be a commensurate reduction in potential disturbance or damage of the land surface as a result of fewer workers and less equipment. As with the conventional survey, several additional aircraft flights per week would be required for resupply of explosives. A great deal more noise would be generated by above ground explosives. This would undoubtedly be disturbing to any birds or mammals within earshot. Early and/or late winter operations, overall, would likely have no long or far reaching effect inasmuch as relatively few numbers of animals are present at that time. There could be some temporary interference with Native subsistence activities during these periods if caribou or other food species were disturbed by seismic activity. The disturbance effect to animals would probably be greater with the air shot technique than it would with a conventional operation.

Winter Exploration by Helicopter

At the present time, most oil and gas exploration activities on the North Slope and Beaufort Sea occur following freeze-up and continue until sea ice or land surface become unsafe or unsuitable for the use of cat-trains. Work may begin in November, but often snow and ice conditions are not adequate for the support of the heavy equipment until December. In recent years, nearly all winter seismic work on the North Slope has utilized the mechanical vibration technique in conjunctions with cat-trains. During mid-winter, aerial logistical support is restricted almost entirely to fixed-wing aircraft. Use of helicopters becomes hazardous as a result of darkness, snow storms, wind, and frequent white-out conditions. Also, due to the extreme weight of equipment used in the vibration technique, helicopter-supported vibration operations are not feasible.

However, there are two winter periods--early and late winter--during which weather and daylight are sufficient to warrant serious consideration of helicopter-transported conventional or air-shot seismic programs. Should this method be determined to have too limiting an application due to the uncertainties of weather, it should be considered as an adjunct to winter surface vehicle operations, concentrating in those areas determined to be most susceptible to surface damage by cat-train operations, or it could be used in those critical wildlife areas which should be avoided by summer helicopter operations.

Physical Environment

Of the four technically feasible methods of conducting a seismic program, a helicopter-transported winter operation would result in the least physical impact to geological phenomena and water quality. There would likely be little or no permafrost degradation and virtually no soil disturbance or potential soil erosion into streams. Air pollution, minor and short-lived with any of the alternatives, would also likely be less with helicopters. No large diesel engines would be utilized and the period of activity would be shorter than would likely occur with a cat-train operation. Perhaps the greatest physical impact would occur at sites selected as personnel camps and logistical support areas. For reasons of efficiency, economy,

and safety, camp/supply bases would have to be located within reasonable flying time from survey areas. Most of the coastal plain could be reached from existing airstrips on ANWR if made available. Thus little additional impact would occur. In some instances it may be necessary to establish temporary bases where none now exist. Impacts would be minimized by restricting such sites to the least sensitive areas, such as beaches or barren river bars. Special use permits issued by the Regional Director would contain terms and conditions governing the siting of airstrips and other support facilities.

Biological Environment

Vegetation and Soils

Winter exploration by helicopter would result in the least potential adverse impacts to vegetation and soils of any of the methods considered. Following a helicopter-transported winter seismic operation, there would likely be no discernible evidence of seismic activity by the end of the first summer. Vegetation disturbance from equipment and shot holes would be minimal with either technique. Helicopters would leave little, if any, evidence of vegetation disturbance or soil erosion except in fuel storage, handling, and refueling areas.

Fish and Wildlife Populations and Behavior

Caribou

The migrating Porcupine Caribou Herd arrives on the ANWR coastal plain in early May. Calving occurs in late May and early June. The location of calving grounds can vary from year to year but the preferred sites are the snow-free areas of the Arctic foothills. Although calving occurs in a variety of habitats from wet tundra to dry ridges, most arriving cows seek out dry, snow-free upland tussock meadows of the foothills to birth their calves. Helicopter-transported seismic operations, if initiated in March, could probably be carried well into May on portions of the refuge unoccupied by calving caribou. Seismic operations would have to be flexible, with earliest work occurring in those areas most likely to attract calving caribou. As the season progresses, there is a possibility that helicopter operations could continue on through April and early May in areas removed from caribou concentration or calving grounds. Such operations could be reinitiated on the western side of the study area as Porcupine caribou leave on their eastern migration following the calving period.

Early winter seismic work could have a potentially greater impact on the Central Arctic Caribou Herd due to the fact that some of the herd may remain on the ANWR coastal plain year-round, especially during "mild" winters. Activities would have to be flexible enough to avoid concentrations of these animals. Small groups and individuals would be difficult, if not impossible, to avoid. However, it would be well past the calving season, and it is expected that most animals would avoid direct or close contact with helicopters and seismic crews with a minimum of distress or disturbance of normal behavior patterns.

The requirements of the proposed regulations regarding caribou described under "Winter Seismic Exploration by Ground Vehicle" also apply here.

Muskoxen

The same factors potentially affecting muskoxen during ground vehicle winter seismic operations would be present in a helicopter-transported winter operation. The main impact would be disturbance from sound and humans in the area. Helicopters flown close to muskoxen would likely have a greater impact than would fixed-wing aircraft, with a potential for disruption of normal behavior and causing the animals to run. This impact can be prevented by avoiding areas occupied by muskoxen. Because muskoxen are relatively sedentary, once bands are located, helicopter flights and operations can be directed a safe distance away with little chance of disturbance.

The requirements of the proposed regulations regarding muskoxen described under "Winter Seismic Exploration by Ground Vehicle" method are also applicable here.

Other Mammals

Noise disturbance would be greater with helicopters than with ground vehicles. Denning brown and polar bears may abandon dens if activity occurs too closely or for too long a period. Wolves, wolverines, and fox would likely suffer no direct impact, although prey animals, particularly caribou, may be sufficiently displaced to cause some temporary but insignificant alteration in feeding habits and distribution of predators. Another potential impact would be the attraction of bears and foxes to waste disposal sites. The proposed regulations prohibit feeding wild animals and leaving garbage or edibles in a place which could attract wild animals. They also require that garbage be kept in covered animal-proof containers prior to incineration, and that only previously approved exploratory activities be permitted to occur from November 1 through April 15 in polar bear denning special use areas, as defined by the Regional Director.

Birds

Most waterbirds arrive in the study area in late May and depart before the end of September. Some leave as early as mid-July, while a few may migrate through the area as late as mid-October. Winter seismic helicopter operations, like winter ground operations, would not interfere with waterbirds during the critical breeding and nesting period. There would be some possibility of overlap with the earliest and latest migrants. Provided that helicopter flights and surveying activity avoided concentrations of birds, impacts would likely be minor at those times. The proposed regulations require that no helicopters be operated in active waterbird nesting or staging areas.

Fish

The proposed regulations prohibit detonation of explosives closer than one-eighth of a mile from any river, stream, spring, or lake which supports fish or fish eggs; however, explosives may be used on lakes or rivers which are frozen to the bottom (including bottom sediments), provided that the timing and location of the detonation of explosives are approved by the Regional Director in advance.

Threatened and Endangered Species

Neither bowhead or gray whales nor peregrine falcons are present near or within the study area during the winter months; thus, they would not be subject to impact.

Human Environment

Socioeconomics

Establishment of helicopter-support base camps at or near Kaktovik or any other areas where local people are seasonally present would create a temporary disruption of normal life style and/or subsistence activity. Although subsistence species would not become less abundant, disturbance of animals by helicopter activity could influence the taking of animals. This might be a more severe impact from helicopters than from cat-trains, in that helicopters would probably have a greater disturbance effect; however, the period of impact would be shorter. Overall, socio-economic effects on Native communities would be minor and of relatively short duration, provided that cultural resources are considered thoroughly during the review of exploration plans.

Archeology

The potential for adverse impact would be less with a winter helicopter-transported seismic operation than with any other methods. Surface disturbance would be minimal and snow cover and frozen ground would significantly reduce any possibility of site damage or disturbance by seismic crews or equipment.

Recreation, Wilderness, and Esthetics

The winter helicopter-transported seismic operation would have the least potential impact of the seismic methods considered. There would likely be little evidence of seismic activity either from the ground or the air by the end of the first summer season. There is little outdoor recreation associated with the ANWR during the winter months; therefore, impacts would be minor.

Comparison of Seismic Techniques

As explained in chapter II, the mechanical seismic vibration (Vibroseis) technique requires ground vehicles to carry the required heavy equipment. The conventional survey method (below-ground explosives) could require large helicopters and additional flights between spreads if heavy drills were used, which would require that they be moved in two or three separate sections. Smaller helicopters would suffice for transporting drills where shallow shot holes are required. Helicopter activity would be considerably greater with a conventional operation than by the air-shot (Poulter) technique. Since drills are not required with air-shot surveys, smaller helicopters could be used to transport of crew, supplies, and equipment.

Summer Seismic Exploration by Ground Vehicle

Use of tracked or wheeled vehicles for seismic work during the summer (ice-free) months is not feasible on the ANWR due to the unavoidable significant irreversible impacts that would occur. The regulations prohibit the use of surface vehicles in the summer and require their use be restricted to winter months under

Typical subsistence activity, harvesting caribou. Sadlerochit River near the springs.

Kaktovik villagers plucking ptarmigan, Arctic National Wildlife Refuge, near the Hulahula River. Photographs by C. Wentworth, U.S. Fish and Wildlife Service, April 1979.

Winter fishing on the Hulahula River, Arctic National Wildlife Refuge. Photographs by C. Wentworth, U.S. Fish and Wildlife Service, April 1979.

conditions of suitable protective cover. Section 1002(d) expressly prohibits the carrying out of exploratory activity during caribou calving and immediate postcalving seasons. This effectively precludes such activity in portions of the ANWR from the last week in May through June.

For summer seismic operations utilizing ground vehicles, damage from processed hydrocarbon spills, breakage of plant parts, compression of standing dead vegetation, and displacement of tussocks and/or mosses would be the most noticeable types of impacts after one growing season. After five growing seasons, thermal erosion in vehicle tracks would likely be the most noticeable impact, but compression of the organic mat and displacement of tussocks would still be noticeable in many landcover types. The most significant impacts are hydraulic and thermal erosion, which results in progressive deterioration of the ground surface. Summer seismic operations are likely to cause heavy damage in all the well-vegetated tundra types. In addition, this method could result in progressive damage or destruction of cultural resources.

All three seismic survey methods utilizing ground vehicles in the summer would result in disturbance of mammals and waterbirds. This would range from physical destruction of dens and nests to disruption of bird breeding activity, abandonment of nests, interference with waterbird staging and migrating activity, and additional stress in some areas to caribou at a critical period during which females are in their poorest condition as a consequence of calving and the nuisance of insects. The presence of ground vehicles and the associated sound and human activity would result in considerable, although temporary, alteration of mammal and bird behavior. The impacts, for the most part, would be very similar to reaction to helicopters, particularly in situations where there was considerable activity in a limited area, with repeated aerial passes and frequent touchdowns or landings. One major difference is that ground vehicles would cause physical destruction of nests or newly hatched waterbirds if used during the nesting period. The proposed regulations require that no exploratory activities be allowed from May 10 to July 15 in caribou calving and postcalving special areas, that no helicopters be operated in the summer within areas of waterbird nesting or staging, and that ground vehicles be operated only in the winter under conditions of adequate protective cover.

Use of ground vehicles during the summer could result in significant adverse impacts to fish habitat. Accumulation of debris, which could result from stream crossings, could result in barriers to fish migration. Erosion and siltation caused by crossings, and traffic adjacent to streams, could affect fish egg incubation and hatching survival. Direct mortality of eggs and fry could result from movement of equipment over spawning areas. Benthic organisms, which provide essential food for fish, could be destroyed by wheeled or tracked vehicles and smothered by the settlement of disturbed soils.

Intensive feeding by the endangered bowhead whale occurs in nearshore waters during the summer (Lowry and Burns, 1980; Richardson and Fraker, 1981). Noise disturbance during this period by above-ground air-shot explosives would not likely disrupt feeding or cause any change in the migration path. Due to the localized nature of the exploration activities, there should be no impact to whales. Also, there should be no effect on the success of Kaktovik residents hunting whales.

Any human activity, including the use of ground vehicles or aircraft, in the immediate vicinity of nesting endangered peregrine falcons poses a threat to the nesting success. During migration or while away from the nest site, peregrines are less sensitive to disturbance. Although peregrine nesting has not been recently documented within the Arctic coastal plain, surveys of potential nesting habitat-such as the foothills of the Sadlerochit Mountains, where rivers have cut cliffs or bluffs in the coastal plain--will be surveyed annually for eyries, which must be avoided during the nesting season.

Summer Seismic Exploration by Helicopter

Helicopter support would be limited to the conventional and air-shot techniques.

Physical Environment

Whereas ground vehicles could cause extensive, long-term damage to sensitive tundra terrain, which in turn could result in soil liquifaction and subsidence, erosion, water contamination, and esthetic degradation, the physical impacts attributable to helicopters are very minor.

Dust could be a local air pollutant in the vicinity of staging areas or air strips that are not snow or ice-covered. The primarly impact of dust in the air is reduced visibility at, or near, the dust-producing source. Fallout of dust on the landscape produces secondary impacts, such as increasing the melt rate of snow by decreasing its albedo. This would be a very localized effect of temporary duration.

Biological Environment

Vegetation and Soils

If summer seismic surveys were supported entirely by air, the impacts to the physical environment and to vegetation would be less than those occurring with either a summer or winter ground vehicle operation. Increased fuel requirements with such an alternative increases the potential for fuel spills where fuel is stored or refueling occurs. The proposed regulations require that all hazardous substances be contained, controlled and cleaned up in accordance with hazardous substances control and contingency plans that applicants must submit to the Regional Director for approval. They also require that any spills or leakage of such substances be reported immediately or as soon as communication is possible, and that fuel storage sites be approved by the Regional Director.

Fish and Wildlife Populations and Behavior

Caribou

Large numbers of Porcupine and Central Arctic caribou cows use the study area from mid- to late May through June for calving. Both herds commonly form into large postcalving aggregations in the study area during late June to mid-July. Caribou are particularly sensitive to disturbance during calving and postcalving activities.

Potential effects of a helicopter-transported seismic program on both herds would vary greatly, depending on the period of summer. The most adverse time

would probably be during May through mid- to late July (depending on the annual variation of caribou use). Helicopter seismic activities could interfere with caribou use of critical calving and postcalving areas, with displacement from preferred habitats resulting in reduced productivity (Calef and Lent, 1976). Disturbing the calving grounds could also interfere with or prevent the establishment of the cow-calf bond essential to the calf's survival. When maternal bonds are not formed and separation occurs, calf mortality is greatly increased (Calef and Lortie, 1973). In addition, caribou, especially parturient females, are at the lowest ebb of the annual physiological cycle during May and continuing through the period of intense insect harassment in July, and their energy budget is the most critical at this time (Dauphine, 1976; White and others, 1981). Disturbance of nursery bands and postcalving aggregations by helicopters could initiate stampedes, causing adults and calves to be trampled and injured. Stampedes would also increase the number of separations between cows and calves and could cause significant mortality. Above-ground (air-shot) detonations at this time could cause additional disturbance.

In a review of several studies of aircraft disturbance on caribou, Davis and Valkenburg (1979) concluded that during calving and postcalving periods, a minimum elevation of 660 m above ground level should be maintained during overflights to prevent mortality of young caribou. They also concluded that helicopters operating at low levels (below 100 m) cause greater disturbance to caribou than light fixed-wing aircraft and are generally a greater harassment to caribou.

Postcalving aggregations of Porcupine Caribou generally begin moving eastward from their calving areas during the end of June and usually pass into Canada during the first half of July. However, this movement is variable, and it is not uncommon for portions of the herd to remain in the study area throughout the summer. Caribou of the Central Arctic Herd may remain in the study area after calving, primarily in the Canning River Delta and Camden Bay. These areas provide important insect relief habitat. Up to 1,000 or more caribou could be affected in these areas by a helicopter seismic program. However, after August these animals would no longer be found in large herds, and helicopter disturbance would have a greatly reduced impact.

The flexibility of a helicopter operation provides opportunity to avoid caribou concentrations during periods of occupancy and to return to such areas after the caribou have departed, thereby reducing the potential for impacts.

The requirements of the proposed regulations regarding caribou described under "Winter Seismic Exploration by Ground Vehicle" method are also applicable here.

Muskoxen

Muskoxen are susceptible to disturbance from aircraft and ground activities. Specific impacts and proposed regulations are discussed in the "Winter Exploration by Helicopter" method. Summer disturbance would be similar, except for calving activity. The proposed regulations permit only limited exploratory activity in muskoxen calving special areas from April 15 to June 1.

Moose

Relatively small numbers of moose use the ANWR study area in summer and may be subject to disturbance by low-flying aircraft. McCourt and others (1974) reported that moose reacted to a fixed-wing aircraft flying at altitudes less than 180 m above ground level. Strong reactions to aircraft flying at altitudes of 60 m were more common (2 of 15 cases); however, in 7 of 16 cases, moose showed no reaction to aircraft flying at altitudes below 60 m. Moose did not react to aircraft flying at altitudes above 180 m. The type of aircraft affects the degree of reaction to overflights, with helicopters being much more disturbing than fixed-wing aircraft (Klein, 1973). Reactions by moose to overflights are also dependent upon habitat type. Mould (1977) reported that moose on open tundra reacted more frequently to passing aircraft than when they were located in wood cover types. Moose are also more sensitive to disturbance during periods of mating, calving, and postcalving.

The ultimate effect of helicopter disturbance upon moose using the study area is unknown. Displacement of moose from riparian or other habitat types as a result of a summer helicopter seismic program would probably be short-term, and moose could be expected to reoccupy these sites.

Marine Mammals

Summer seismic surveys would have no impact on marine mammals since activity would be restricted to land. The few seals found in the nearshore waters during the summer would not likely be affected.

Birds

The potential impacts of summer seismic operations on migratory birds include (1) disturbance due to increased human activities, including air traffic, (2) locally increased predation due to animal attraction to camps, (3) direct effects due to oil (refined fuel and lubricant) spills, and (4) habitat alterations.

In general, disturbance to birds causes a number of short-term impacts: lower nesting densities, lower hatching success, nest abandonment, increased stress during molting, increased predation on eggs or chicks, and increased stress during staging and migration.

The effects of long-term disturbance are less known. Experimental disturbance studies conducted on the Yukon North Slope, 1972-75, documented short-term (1 day to several weeks) effects on nesting, molting, and staging birds but could only speculate on the long-term effects and recommended further long-term disturbance research (Platt and Tull, 1977; Schweinsburg, 1974; Gollop and others, 1974a, b; Schweinsburg and others, 1974; Salter and Davis, 1974; Gollop and Davis, 1974; Wiseley, 1974; Davis and Wiseley, 1974; and Patterson, 1974).

Snow geese are particularly sensitive to disturbances, including aircraft overflights at altitudes below 3,000 m and especially below 55 m (Barry and Spencer, 1976; Davis and Wiseley, 1974; Salter and Davis, 1974; Wiseley, 1974). Snow geese apparently do not adjust well to aerial disturbances since they react to aircraft overflights on the wintering grounds, many areas of which have had frequent aircraft traffic for decades (Spindler, oral comm., 1981). Wiseley (1974) found that snow geese feeding flocks rarely approached closer than within 800 m of

ground-based noise simulation. Snow geese abandoned the Howe Island nesting colony on the Sagavanirktok Delta for the remainder of one nesting season following frequent helicopter overflights (Gavin, 1980; Welling and others, 1981). Barry and Spencer (1976) found that gulls and jaegers took exposed eggs in snow goose nests when the adults were flushed by a helicopter.

Canada geese breeding on the arctic coastal plain on ANWR were easily disturbed early in incubation (Spindler, 1978a) and, when forced off their nests by human presence, were slow in returning, hence exposing the eggs or nests to egg-eating predators (Martin and Moitoret, 1981).

Aircraft disturbance to barrier island and shoreline colonial nesting birds is of concern because aircraft traffic tends to follow the coastline when ceilings and visibility are low. Gollop and others (1974b) found that helicopters were more disturbing to nesting brant, common eiders, glaucous gulls, and arctic terns than fixed-wing aircraft on the Yukon coast. Of those species, brant and arctic terns were most susceptible. Human presence in nesting colonies was more disturbing (by interrupting incubation and exposing eggs to avian predators) than aircraft overflights.

The energy required for premolt movements, coupled with the high energy demands of molting, places a great deal of physiological stress on waterfowl using the lagoons. Sterling and Dzubin (1967) felt that continued long-term harassment could cause ducks to abandon sheltered molting areas for less desirable, but undisturbed, areas. This could adversely affect survival of molting waterfowl.

Raptors begin nesting along bluffs and cliffs as early as April. They are especially sensitive to disturbance during the nesting period. The effects of disturbance on nesting gyrfalcons was studied by Platt and Tull (1977). They reported: "There was no significant difference in the productivities of successful gyrfalcon nests between those nests that were disturbed by helicopter overflights and those that were not disturbed." However, they noted that disturbed birds did not reoccupy nest sites the following year, possibly choosing a new nest site or not nesting at all. Helicopters "invariably" disturbed gyrfalcons by passing at an altitude of 150 m. Significantly less disturbance occurred at 300 m and none at 600 m. Gyrfalcons became adjusted to human approach on foot over a several-day period.

The proposed regulations prohibit helicopter operations in the summer within waterbird nesting or staging areas. Also, they prohibit wildlife harassment and require that all hazardous substances be contained, controlled, and cleaned up in accordance with a permittee's hazardous substances control and contingency plan. Additional terms and conditions necessary to protect avian species will be incorporated into special use permits.

Fish

Summer helicopter seismic exploration should have no identifiable impact on fish or fish habitat, provided that the proposed regulations and any special use permit terms and conditions are adhered to. The proposed regulations require that no water be removed from any stream, lake, river or subsurface source without permission of the Regional Director; no explosives be detonated closer than one-eighth of a mile from any river, stream, spring, or lake supporting fish or fish eggs; no operations be conducted in a manner that will impede the passage of fish,

disrupt spawning areas or block or change the character or course of, or cause significant siltation or pollution of any stream, river, pond, pothole, lake, lagoon, or drainage system; all hazardous substances be contained, controlled, and cleaned up in accordance with the permittee's approved hazardous substances control and contingency plan; no fuel storage facilities be placed within the annual flood plain of fish-bearing watercourses or closer than 100 feet to a waterbody; no vehicle refueling occur within such areas, and all fuel storage sites be approved by the Regional Director.

Threatened and Endangered Species

For a discussion of possible impacts to the three endangered species potentially affected by summer seismic activity (bowhead and gray whales and peregrine falcons), refer to the discussion of summer seismic exploration by ground vehicle in this chapter. There would likely be little difference in the potential impacts to these species with either a surface vehicle seismic operation or one conducted entirely by helicopter. In either case there is little likelihood of any identifiable impact to the bowhead or gray whales. Both operational methods have the potential of impacting peregrine falcons. Biological assessments required by Section 7(c) of the Endangered Species Act are being prepared to determine whether or not activities may affect any of the three listed species.

Human Environment

Socioeconomics

Summer exploration would impact local subsistence hunting and fishing. These effects would not be a great deal different from those that would result from summer seismic exploration utilizing ground vehicles, although a helicopter-transported operation may provide less local temporary employment opportunity because of the smaller crews required. Noise would be a more significant factor with helicopters during given periods and could result in reduced hunting success in some instances. Although inland hunting is pursued much less during the summer than during the winter, coastal subsistence activities are greatly increased; thus, any significant or prolonged seismic activity along the coast (i.e., helicopter flying) could be temporarily disruptive of subsistence activities.

Archeology

The major archeological impact associated with a summer seismic helicopter-transported operation would be the potential disturbance of the ground surface by frequent landings and human activity.

The proposed regulations allow the Regional Director to reasonably restrict exploratory activities in areas of known cultural resources or areas of predicted high probability of containing cultural resources to minimize or avoid disturbance. They also prohibit ground vehicles from passing over or through known cultural-resource sites containing standing structures, prohibit seismic trains from camping on known cultural-resource sites, and prohibit discharge of petroleum or petroleum products on the surface of known cultural-resource sites.

Recreation, Wilderness, and Esthetics

Summer seismic operations restricted to the use of helicopters would create a greater disturbance to recreationists than would cat-trains. This would be a temporary effect, with little or no long-term physical evidence of seismic activity.

Comparison of Seismic Techniques

The major impact associated with a summer seismic helicopter-transported operation would be the disturbance factor related to noise and activity associated with low-flying helicopters, frequent landings, and human activity on the ground. This would be largely the same with either the air-shot or conventional techniques. Greater noise associated with numerous above-ground explosives from the air-shot technique would be largely offset by the more numerous flights and larger field crews associated with the conventional technique. Impacts could be particularly damaging over the short term if helicopters were permitted in waterbird breeding, nesting, and staging areas. This is prohibited by the proposed regulations. (The vibration technique is inapplicable because of the inability of helicopters to transport the heavy equipment required).

Unavoidable Adverse Impacts

Each of the four seismic methods evaluated in detail in this chapter will result in impacts which cannot be prevented or totally offset. Some will result in minor impacts, while significant damage would result from the use of ground vehicles in the summer. The proposed regulations are designed to ensure the prevention of significant impacts.

There are basically three different types of adverse affects attributable in varying degrees to each seismic method: (1) animal disturbance, comprised of temporary, although potentially dramatic behavioral reactions resulting in disruption of breeding and migratory patterns; (2) habitat disturbance, including vegetation destruction and soil compaction, erosion and liquifaction, and visual degradation; and (3) human disturbance, including disruption of sociocultural isolation and privacy and possible disruption of subsistence activities, and disturbance or destruction of cultural resources.

Winter Seismic Exploration by Ground Vehicle

Some soil, vegetation, and cultural resource disturbance is inevitable with a cat-train operation. Even with minimum requirements of snow depth there would likely be some soils, vegetation, or archeological site disturbance. This is particularly likely in instances where blading or plowing of deep snow may be required for access, where hilly terrain is encountered, or where insufficient snow depth is prevalent in uplands. Also, some sensitive areas, such as tussock tundra, may be susceptible to unavoidable damage regardless of snow cover. The proposed regulations are designed to ensure that soil, vegetation, and cultural-resource disturbance is kept at an acceptable level.

Noise of equipment and human activity adds another dimension to unavoid able impacts. Although the presence of wildlife is at its lowest ebb during the winter, there is opportunity to harm those which remain. Of most concern are polar bears and muskoxen. The total number and location of denning female polar bears on the refuge is presently unknown. Muskoxen are particularly vulnerable to

disturbance because of their limited winter territory and inherent sensitivity. Implementation and enforcement of the proposed regulations and special use permit terms and conditions will prevent exploratory activities from causing significant adverse impacts to these species.

The vibration and conventional seismic techniques would result in essentially identical impacts, inasmuch as the size of crew and number of required vehicles are essentially the same with either operation.

The air-shot technique would have a greater disturbance impact on animals than the other two techniques because of the considerable noise related to the use of above-ground explosives. On the other hand, it would have somewhat lesser potential impact on soils and vegetation in that heavy vibrating machines or drill rigs would not be necessary.

Winter Seismic Exploration by Helicopter

Surface impacts associated with this operation would be very limited. The greatest physical impacts would be associated with temporary camps, which would be located within reasonable flying distances from work areas. Properly located, however, winter camps would have only minor effect. It is unlikely that a helicopter-transported seismic operation during the winter would leave any physical evidence by the end of the first summer.

Noise would be a considerably greater factor with this method than the use of cat-trains because of the greater and more far-reaching sound caused by low-flying helicopters along the seismic lines. Noise disturbance could cause abandonment of dens by polar bears, and muskoxen would be very vulnerable to accidental or purposeful harrassment. The proposed regulations provide restrictions designed to prevent these adverse impacts. Although relatively few caribou winter on the ANWR, those present could be temporarily forced out of preferred feeding areas. Overall, disruption to animals would be relatively short term.

Noise associated with the air-shot method would be an additional disturbance factor to wintering animals. Less noise would result from the conventional use of below-ground explosives; however, this method could require larger helicopters and more flights should some of the larger drill rigs be required.

Overall, helicopter-transported seismic exploration would have the least adverse environmental impact of all the viable methods. However, there are limitations and disadvantages of this technique. The risk to human life is much greater with helicopters than with surface vehicles, particularly during winter. Hazardous flying conditions resulting from prolonged darkness and severe weather conditions precludes serious consideration of extensive helicopter use during the mid-winter period--roughly mid-October through mid-March.

With the advent of breakup and the return of migratory waterfowl and caribou, exploratory activities in those critical areas will be restricted or prohibited, either by the requirements of the proposed regulations or by special use permit terms and conditions.

Summer Seismic Exploration by Ground Vehicle

This would be the most damaging method considered for oil and gas exploration. Both the human and biological environments would be significantly impacted. Cat-train trails would be visible from the air for many years, and local impacts consisting of soil subsidence and erosion, degradation of water quality, soil compaction, damage to the vegetative mat, destruction of cultural resources could be severe. Disruption of breeding and migration patterns of waterbirds and caribou could cause locally dramatic short-term changes in distribution and habitat use, and would almost certainly cause a temporary drop in productivity of some species. Although such impacts would probably be reflected in the populations for only a few years, there could be some minor impact to subsistence uses until populations became fully reestablished. The proposed regulations prohibit the use of ground surface vehicles in the summer and require that ground vehicles be operated in winter only when and where there is adequate protective cover.

Summer Seismic Exploration by Helicopter

Physical impacts would be comparatively minor with helicopter-transported operations. Essentially no damage would accrue to vegetation, soils, or water. Sound and human activity would be the major impact. Helicopters would also be disturbing to local human inhabitants, who are often camping, hunting, fishing, and traveling along the coast at this time of year. As with a winter helicopter operation, noise would be considerably greater with the air shot technique than it would be with use of below-ground explosives. This increased disturbance factor would be offset to some degree by the use of smaller helicopters and fewer flights than would be required to transport drill rigs used in the conventional method of seismic exploration. Impacts to wildlife would be substantially avoided by restricting operations to areas devoid of significant concentrations of birds and mammals as required by the proposed regulations.

SHORT-TERM USES VERSUS LONG-TERM PRODUCTIVITY

There would be little loss in long-term productivity associated with any of the oil and gas exploration methods. Summer work utilizing ground vehicles would result in the longest lasting effects; however, this activity is prohibited by the proposed regulations. Although it is predicted to be minor, changes in long-term biological productivity cannot be accurately predicted. If any alternative resulted in modification of migratory routes or traditional wildlife use areas (e.g., snow goose or oldsquaw staging areas; caribou or muskox calving areas) the long-term productivity of the habitat would not be degraded, but the productivity of the flock or herd could be. In time, physically damaged areas would probably recover to approximate preproject levels of productivity. Of more lasting effect would be visual degradation associated with seismic exploration. Some scars could be visible for a number of decades, if not indefinitely. Activities utilizing helicopter-transported techniques would have relatively short-term impact. Winter use of cat-trains could result in visual scars for some time on a localized basis. However, they would be significantly less than would result from summer cat-train operations. Properly conducted in accordance with the proposed regulations accompanying this EIS, there should be no significant sacrifice of long-term productivity on the refuge. A major concern is that no damages be permitted which would jeopardize the current option of designating the coastal plain of the ANWR as a Wilderness Area.

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

There would be no long-term effects of oil and gas exploration which would directly constitute an irreversible and irretrievable commitment of the physical or biological resources of the ANWR coastal plain. Evaluation of any long-term adverse effects due to further exploration, development or production of any discovered oil and gas will be addressed in the report to Congress required by section 1002(h) of ANILCA.

CHAPTER V

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Reed S. Glesne	Fish, aquatic habitat	M.S., Aquatic Biology, Tennessee Technological University; B.S., Fisheries Science, University of Wisconsin Graduate studies, Water Resource Engineering, Tennessee Technological University
Rodney G. Jackson	Mammals	Ph. D., Biology, University of Texas; M.S., Zoology, University of Texas; B.S., Biology, Beloit College

Name	EIS Responsibility	Education
U.S. DEPARTMENT OF THE INTERIOR--Continued		
U.S. Fish and Wildlife Service--Continued		
William L. Kirk	Vegetation	Ph. D., Botany/Biology, Texas A & M University; M.A., Biology Instruction in Postsecondary, University of Miami; B.S., Zoology/Biology, University of Miami
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David G. Patterson	Visual resources, recreation	B.S., Wildlife Management, Humboldt State College; A.A., Administration of Justice, American University; A.A., Business Administration, Fullerton College
Roland Pression	Graphics data	B.A., Cartography College Technique Carrosserie, (Paris, France); Fellow, American Cartographic Association; Wildlife Studies Audubon Society, Graduate studies, Computer Cartography, University of Alaska
Scott L. Schliebe	Marine mammals	B.S., Fish and Wildlife Management, South Dakota State University
Robert L. Seemal	Wilderness	M.S., Forestry, University of Minnesota; B.S., Forestry, University of Minnesota

Name	EIS Responsibility	Education
U.S. DEPARTMENT OF THE INTERIOR--Continued		
U.S. Fish and Wildlife Service--Continued		
Michael W. Smith	Fisheries	B.S., Wildlife and Fisheries, Texas A&M University
John L. Trapp	Seabirds	B.S., Wildlife Biology, Michigan State University
M. Pat Wennekens	Coastal/marine biological environment	Ph. D., Oceanography, University of Washington; B.S., Fisheries, University of Washington
Cynthia Wentworth	Socioeconomics	B.A., Economics, Tufts University; Graduate studies, Natural Resources Economics, Inupiaq Language, Subsistence, University of Alaska
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Wilma J. Zellhoefer	Mammals	B.A., Biology, Whittier College
U.S. Geological Survey and Minerals Management Service		
William Acevedo	Landcover	B.S., Geology, San Jose State University
James E. Callahan	Geophysical operations scenarios	M.S., Geology Emory University; B.A., Geology, Emory University
Oscar J. Ferrians, Jr.	Geologic hazards	M.S., Geology, Washington State University; B.S., Geology, Washington State University
Leonard Gaydos	Landcover	M.A., Geography, San Jose State University; B.A., Geography, San Jose State University

Name	EIS Responsibility	Education
U.S. DEPARTMENT OF THE INTERIOR--Continued		
U.S. Geological Survey and Minerals Management Service--Continued		
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Charles E. Sloan	Hydrology, climate	B.S., Geological Engineering, Kansas University
Office of Surface Mining Enforcement and Reclamation		
Roger D. Highland	Cartographer	Undergraduate studies, Engineering, Northeastern Junior College
Carol B. Hurr	EIS technical editor, printing specialist	B.A., Secondary Education, Occidental College; Graduate studies, Geology, Colorado School of Mines
William G. Weist	Backup editor	M.S., Geology, University of Colorado; B.A., Geology, Amherst College; Advanced study, Hydrogeology, University of Arizona
CONTRACTORS		
Institute of Arctic and Alpine Research, University of Colorado		
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Name	EIS Responsibility	Education
CONTRACTORS--Continued		
Institute of Arctic and Alpine Research, University of Colorado--Continued		
Patrick J. Webber	Vegetation	Ph. D., Plant Ecology, Queens University; M.Sc., Biology, Queens University; B.Sc., Botany/Zoology/Chemistry, Reading University
Institute of Polar Studies and Department of Agronomy, Ohio State University		
K. R. Everett	Soils	Ph. D., Geology, Ohio State University; M.S., Geology, University of Utah; B.A., Geology, University of Buffalo
U.S. Army Cold Regions Research and Engineering Laboratory		
Jerry Brown	Soils	Ph. D., Soils, Rutgers University; B.S., Agriculture, Rutgers University
Richard K. Haugen	Climate	M.A., Geography, Michigan State University; B.S., Biology/Geography, Wisconsin State University

CHAPTER VI

PUBLIC INVOLVEMENT

SCOPING

Given the controversial nature of proposed oil and gas exploration on the Arctic National Wildlife Refuge, and the widespread interest of both environmental interests and industry with respect to the proposal and its possible effects on fish, wildlife, and other resources, an effort was made to enlist widespread public interest and involvement in the development of the EIS and the exploration guidelines (regulations).

A Notice of Intent (NOI) to develop an EIS and regulations for oil and gas exploration on the ANWR was published in the Federal Register, Tuesday, July 14, 1981. The notice announced public meetings which were subsequently held at Anchorage, Fairbanks, Kaktovik, Arctic Village, and Barrow, Alaska, and Washington, D.C., on August 13, 17, 18, 19, 24, and September 1, 1981, respectively. A public information package was made available to all attendants of the public meetings. In addition to the NOI, a request for public review and comments to help form proposed rules for governing exploration in the ANWR and for determining the parameters of the EIS was widely publicized via a number of media. This public announcement was provided to both the Associated Press (AP), Anchorage, and United Press International (UPI), Seattle (Anchorage desk). It was also provided directly to eight Alaskan newspapers, seven magazines and/or periodicals, and was distributed to some 2,000 recipients of the Department of the Interior newsletter, many of whom are individuals, organizations, and publications in the lower 48 States. The announcement was also provided to the KBRW radio in Barrow for transmittal to the affected communities on the North Slope. This announcement was distributed some 2 to 4 weeks in advance of the first public meeting in Anchorage on August 13, 1981. Requested comments were accepted until September 1, 1981.

Response to the request for public input was broad and represented a balanced view of concerned individuals, environmental organizations, industry representatives, and State and local agencies. A total of 48 oral statements were made at the 6 public meetings, with representation as follows: 28 private citizens, 3 North Slope Borough and village spokespersons, 9 representatives of industry, 7 representatives of State or national environmental organizations, and 1 State of Alaska official. In addition, a total of 23 formal letters of comment have been received: 4 from environmental organizations, 6 from individuals, 1 from a village corporation, 1 from a Federal agency, and 11 from industry. The above sources of comments were all in response to the public meeting notices.

The scoping process has been further enhanced by considerable additional two-way correspondence, telephone conversations, and meetings between representatives of the Department of the Interior and several State agencies, and numerous in-house meetings and memoranda between the FWS, MMS, and USGS.

Following is the mailing list of the majority of those agencies and individuals receiving copies of this DEIS for review and comment by virtue of their special interest, jurisdiction by law, and/or special expertise. A complete mailing list for the entire distribution is available from either:

Mr. David McGillivary
Alaska Regional Office
U.S. Fish and Wildlife Service
1011 E. Tudor Road
Anchorage, Alaska 99503

or

Mrs. Carol Hurr
Technical Editor for ANWR study
Office of Surface Mining
Western Technical Center
Brooks Towers
1020 - 15th Street
Denver, Colorado 80202

Copies of the DEIS are also available for review at the following libraries:

All Anchorage Public Libraries
All Fairbanks Public Libraries
All Juneau Public Libraries
Arctic Slope Regional Corporation Library
Arctic Village Community Library
Kenai Community Library
North Slope Borough School District Library

DRAFT ENVIRONMENTAL IMPACT STATEMENT INITIAL MAILING LIST*

*The mailing list will be expanded as additional requests for the DEIS are received.

Alaska Communities

Anchorage Chamber of Commerce
Birch Creek Village Council
City of Anaktuvuk Pass
City of Barrow
City of Fairbanks
City of Kaktovik
City of Nome
City of Point Hope
City of Wainwright
Fairbanks Chamber of Commerce
Kaltag Village Council
Kenai Chamber of Commerce

Alaska Communities

King Island Native Community
Koyukuk Village Council
Municipality of Anchorage
Native Village of Eagle
Native Village of Fort Yukon
Native Village of Mount Village
Native Village of Stevens
Native Village of Tanacross
Native Village of Tanana
Native Village of Venetie
North Slope Borough
Northway Village Council
Nulato Village Council
Rampart Village Council
Village of Kalskag

Alaska Native Groups

Alaska Federation of Natives
Aleut Corporation
Aleutian/Pribilof Association
Arctic Slope Regional Corporation
Arctic Village, Village Council
Association of Village Council Presidents
Bering Strait Native Corporation
Bettles Field Community Council
Bristol Bay Native Corporation
Calista Corporation
Chugach Natives, Incorporated
Cook Inlet Native Association
Doyon, Limited
Eskimos, Incorporated
Inupiat Community of Arctic Slope
Kawerak, Incorporated
Kenaitze Indians of Alaska
Koniag, Incorporated
Mauneluk Association
Mentasta Lake Village
NANA Regional Corporation
Nome Eskimo Village
Olgoonik Corporation
Sealaska Corporation
Tanana Chiefs Conference, Incorporated
The 13th Regional Corporation
Traditional Kobuk Council

Alaska State Agencies

Alaska Oil and Gas Conservation Commission
Alaska State Geological Survey
Alaska State Historic Preservation Office
Attorney General for the State of Alaska
Department of Commerce and Economic Development
Department of Community and Regional Affairs
Department of Environmental Conservation
Department of Fish and Game
Department of Health and Social Services
Department of Natural Resources
Department of Policy Development and Planning
Department of Transportation and Public Facilities
Office of the Governor

Environmental Groups

Alaska Center for the Environment
Alaska Conservation Society
Alaska Wilderness Council
Anchorage Audubon Society
Arctic Coastal Zone Manager
Centre for Northern Studies
Ducks Unlimited
Environmental Defense Program
Friends of the Earth
Greenpeace
International Association of Fish & Wildlife
International North Pacific Fish Commission
Intersea Research Corporation
Isaac Walton League
Kachemak Bay Conservation Society
Kenai Conservation Society
Knik Group - Sierra Club
National Academy of Sciences
National Audubon Society
National Wildlife Federation
National Wildlife Refuge Association
Nature Conservancy
North Pacific Fisheries
NRA
Pacific Seabird Group
Sierra Club
Southeast Regional Resource Center
Steering Council for Alaska Lands
The Real Alaska Coalition
The Wilderness Society
Trustees for Alaska
Wildlife Management Institute

Federal Agencies

Alaska Air Command
Advisory Council on Historic Preservation
Alaska Outer Continental Shelf Office
Bureau of Indian Affairs
Bureau of Land Management
Bureau of Mines
Cooperative Extension Service
Council for Alaskan Archeology
Department of Military Affairs
Environmental Protection Agency
FAA AAL-5
Federal Information Center
Minerals Management Service
National Marine Fisheries
NOAA - Haz Materials Resp. Ofc.
National Park Service, Departmental Consulting Archeologist
Naval Arctic Research Laboratory
Office of the Federal Inspector
Office of the Solicitor
Soil Conservation Service
Special Assistant to the Secretary
U.S. Army, Corps of Engineers
U.S. Army, Cold Regions Research and Engineering Laboratories
U.S. Chamber of Commerce
U.S. Coast Guard Marine Safety
U.S. Department of Agriculture, Forest Service
U.S. Fish and Wildlife Service
U.S. Geological Survey
U.S. Weather Service

Industry

Alaska Exploration Corporation
Alaska Industry
Alaska Interstate Company
Alaska Map Service
Alaska Oil and Gas Association
American Petroleum Institute
AMOCO Production Company
ARCO
Battelle Northwest
BP Alaska Exploration, Inc.
Carson Geoscience Company
CGG Offshore
Chevron USA, Inc.
Cities Service Company
Conoco
Cook Inlet Response Organization

Industry

Dames & Moore
Drilling Services, Inc.
Esca Tech. Corporation
Exxon Company, USA
Geodata Corporation
Deodigit
Geo. Co. of Northway, Inc.
Geophysical Corporation of Alaska
Geophysical Services, Inc.
IMCO Services
International Association of Geophysical Contractors
Marathon Oil Company
Mobil Oil Corporation
Nissho-Iwai American Corporation
N.L. Baroid Petroleum
Northern Technical Services
Ocean Technology, Limited
Oil Patch of Alaska, Incorporated
Petty Ray Geophysical, Incorporated
Phillips Petroleum
Placid Oil Company
Resource Development Council of Alaska
Shell Oil Company
Sohio BP Alaska
Standard Oil of California
TAM Engineers
Tesoro Alaskan Petroleum Corp.
Tetra Tech., Incorporated
Texaco, Incorporated
Union Oil Company
Variance Corporation
Western Geophysical Company
Woodward-Clyde Consultants

News Media

Alaska Journal of Commerce
Alaska Magazine
Alaska Radio Network
All-Alaska Weekly
Anchorage Daily News
Anchorage Times
Associated Press
Cheechako News
Cook Inlet Chronicles
District Media Resource Center
Fairbanks Daily News Miner
Juneau SE Empore
Nome Nugget

News Media

Northwest Arctic School District
Outdoor Writers Association
Peninsula Clarion
Petroleum Engineer International
The Alaska Report
The Alaska Review
Tundra Times

State Senators And Representatives

Honorable Donald E. Young
Honorable Ted Stevens
Honorable Frank Murkowski

CHAPTER VII

REFERENCES CITED AND SELECTED REFERENCES

Abele, G., Walker, D. A., Brown, Jerry, Brewer, M. C., and Atwood, D. M., 1978, Effects of low-ground-pressure vehicle traffic on tundra at Lonely, Alaska: Hanover, New Hampshire, U.S. Army Cold Regions Research and Engineering Laboratory, CRREL Special Report 78-16, 63 p.

Acevedo, William, and Walker, D. A., 1982, A Landsat landcover classification of the Beechey Point quadrangle, Arctic Coastal Plain, Alaska: (1:250,000) (In press.)

Adam, K. M., 1973, Winter road study; Appendix VI to Interim report No. 1, Towards an environmental impact assessment of a gas pipeline from Prudhoe Bay, Alaska, to Alberta: Winnipeg, Manitoba, Environmental Protection Board, 236 p.

_____1974, Impact from winter road use and misuse, p. 29-36, in Research reports, v. IV of Environmental impact assessment of the portion of the Mackenzie gas pipeline from Alaska to Alberta: Winnipeg, Manitoba, Environmental Protection Board, 307 p.

Alaska Peregrine Falcon Recovery Team, 1979, Peregrine falcon--Alaska population (Falco peregrinus tundrius, Falco peregrinus anatum):Anchorage, Alaska, U.S. Department of the Interior, Fish and Wildlife Service, Agency Review Draft Recovery Plan, 84 p.

Aleksandrova, V. D., 1970, The vegetation of tundra zones in the U.S.S.R. and data about its productivity, in W. A. Fuller and P. G. Kevan, editors, Productivity and conservation in northern circumpolar lands: Morges, Switzerland, IUCN Publication 16, p. 93-114.

_____1980, The Arctic and Antarctic--Their division into geobotanical areas: Cambridge, England, Cambridge University Press, 247 p.

Ambrose, R. E., 1980, Results of peregrine falcon surveys on the Upper Yukon, Charley, and Colville Rivers, Alaska: Anchorage, Alaska, U.S. Fish and Wildlife Service Report, 20 p.

Amstrup, S. C., 1981, Polar bear research in Alaska--Spring 1981: Denver, Colorado, Denver Wildlife Research Center, 27 p.

Anderson, J. G., 1906, Solifluction, a component of subaerial denudation: Journal of Geology, v. 14, p. 91-112.

Anderson, J. R., Hardy, E. E., Roach, J. T., and Witmer, R. E., 1976, A land use and landcover classification system for use with remote sensor data: U.S. Geological Survey Professional Paper 969, 28 p.

Arctic Environmental Information and Data Center, 1978, Kaktovik foldout, in Socioeconomic profile, NPR-A 105(c) study report: Anchorage, Alaska, prepared for NPR-A task force, 186 p.

Bangs, E., 1982, Moose response to winter seismic activity on the Kenai NWR: Fairbanks, Alaska, Paper presented to the Annual Alaska Interagency Moose Meeting.

Barry, T. W., and Spencer, R., 1976, Wildlife response to oil well drilling: Canadian Wildlife Service Progress Notes No. 67.

Bartels, R. F., 1973, Bird survey techniques on Alaska's north coast: Ames, Iowa, Iowa State University unpublished M.S. thesis, 47 p.

Bee, J. W., and Hall, E. R., 1956, Mammals of northern Alaska on the Arctic Slope: Lawrence, Kansas, University of Kansas, Museum of Natural History, Miscellaneous Publication 8, 309 p.

Beikman, H. M., compiler, 1980, Geologic map of Alaska: U.S. Geological Survey, scale 1:2,500,000, 2 sheets.

Belikov, S. E., 1976, Behavioral aspects of the polar bear, Ursus maritimus, in M. R. Pelton, J. W. Lentfer, and G. E. Folk, Jr., editors, Bears--Their biology and management: IUCN Publications, New Series 40, p. 37-40.

Belon, A. E., Miller, J. M., and Stringer, W. J., 1975, Environmental assessment of resource development in the Alaskan coastal zone based on Landsat imagery: Fairbanks, Alaska, University of Alaska, NOAA/OCS Project Office, Remote-Sensing Data for OCS Studies, Arctic Project Bulletin No. 7.

Benson, C. S., 1981, Reassessment of winter precipitation on Alaska's Artic Slope and measurements on the flux of windblown snow: Final report prepared for the U.S. Forest Service, Rocky Mountain Forest and Range Experiment Station, 54 p.

Bergerud, A. T., 1978, Caribou, p. 83-101, in J. L. Schmidt and D. L. Gilbert, editors, Big game of North America--Ecology and management: Harrisburg, Pennsylvania, Stockpole Books, 494 p.

Bergman, R. D., Howard, R. L., Abrahan, K. F., and Weller, M. W., 1977, Waterbirds and their wetland resources in relation to oil development at Storkersen Point, Alaska: U.S. Fish and Wildlife Service Resource Publication 129, 38 p.

Billings, W. D., and Peterson, K. M., 1980, Vegetational change and ice-wedge polygons through the thaw-lake cycle in Arctic Alaska: Arctic and Alpine Research, v. 12, p. 413-432.

Bliss, L. C., and Gustafson, K. M., 1981, Proposed ecological natural landmarks in the Brooks Range, Alaska: Prepared for the Division of Natural Landmarks, Heritage Conservation and Recreation Service, 175 p.

Blumer, M., 1970, Scientific aspects of the oil spill problem: Woods Hole, Massachusetts, Paper presented at NATO Conference; available in mimeo. form from Woods Hole Oceanographic Institute, 21 p.

Braham, H., and Krogman, B. D., 1977, Population biology of the bowhead (Balaena mysticetus) and beluga (Delphinapterus leucas) whale in the Bering, Chukchi, and Beaufort Seas: National Oceanic and Atmospheric Administration, National Marine Mammal Laboratory-National Marine Fisheries Service, 29 p.

Britton, M. E., 1957, Vegetation of the Arctic tundra, in H. P. Hansen, editor, Arctic biology: Corvallis, Oregon, Oregon State University Press, p. 67-130.

Brooks, J. W., 1978, Status of marine mammal stocks in Alaska: Fairbanks, Alaska, University of Alaska, Paper presented at the 29th Alaska Science Conference, August 17, 1978, 17 p.

Brower, W. A., Diaz, H. F., Prechtel, A. S., Searby, H. W., and Wise, J. L., 1977, Climatic atlas of the Outer Continental Shelf water and coastal regions of Alaska; v. III, Chukchi-Beaufort Sea: National Oceanic and Atmospheric Administration, Alaska Outer Continental Shelf Environmental Assessment Program, 409 p.

Brower, W. A., Jr., Searby, H. W., and Wise, J. L., 1977, Climatic atlas of the Outer Continental Shelf waters and coastal regions of Alaska; Volume III, Chukchi-Beaufort Sea: U.S. Department of the Interior, Bureau of Land Management, Alaskan Outer Continental Shelf Environmental Assessment Program.

Brown, Jerry, 1962, Soils of the northern Brooks Range, Alaska: New Jersey, Rutgers University, unpublished Ph. D. thesis.

_____1966, Soils of the Okpilak River region, Alaska: Hanover, New Hampshire, U.S. Army Cold Regions Research and Engineering Laboratory, CRREL Research Report No. 188, 49 p.

_____1969, Soils of the Okpilak River region, Alaska, in T. L. Pewe, editor, The periglacial environment--Past and present: McGill-Queen's Press, p. 93-128.

_____(editor), 1975, Ecological investigations of the tundra biome in the Prudhoe Bay region, Alaska: Biological Papers of the University of Alaska, Special Report No. 2, 215 p.

Brown, Jerry, and Berg, R., 1980, Environmental engineering and ecological baseline investigations along the Yukon River-Prudhoe Bay haul road: Hanover, New Hampshire, U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) Report 80-19.

Brown, Jerry, Everett, K. R., Webber, P. J., Maclean, S. F., and Murray, D. F., 1980, The coastal tundra at Barrow, in Jerry Brown, P. C. Miller, L. L. Tieszen, and F. L. Bunnell, editors, An Arctic ecosystem--The coastal tundra at Barrow, Alaska: Stroudsburg, Pennsylvania, Dowden, Hutchinson and Ross, p. 1-29.

Burns, J. J., and Eley, T. J., 1978, The natural history and ecology of the bearded seal (Erignathus barbatus) and the ringed sea (Phoca hispida), p. 226-302, in Environmental assessment of the Alaskan Continental Shelf: Annual reports of principal investigators of the year ending March 1977, Outer Continental Shelf Environmental Assessment Program Report, RU 230, v. I, 773 p.

Burns, J. J., and Frost, K. J., 1979, The natural history and ecology of the bearded seal (Erignathus barbatus): Outer Continental Shelf Environmental Assessment Program, Final Report, 77 p.

Burns, J. J., Shapiro, L. H., and Fay, F. H., 1980, The relationships of marine mammal distributions, densities, and activities to sea ice conditions: Outer Continental Shelf Environmental Assessment Program, Environmental Assessment of the Alaskan Continental Shelf, Research Unit 248/249, Contract No. 03-5-022-55, Final Report, 172 p.

Cade, T. J., 1960, Ecology of the peregrine and gyrfalcon populations in Alaska: University of California Publication, Zoology, v. 63, p. 151-162.

Calef, G. W., and Lent, P. C., 1976, Impact on the living environment--Caribou transcripts: Transcripts of the Mackenzie Valley Pipeline Inquiry, v. 106, p. 16158-16279.

Cantlon, J. E., 1961, Plant cover in relation to macro-, meso-, and micro-relief: Office of Naval Research, Grants Nos. ONR-208 and 216, Final Report, 128 p.

Carruthers, D. R., 1976, A study of the influence of seismic exploration on muskoxen and caribou on Banks Island, Northwest Territories: Calgary, Alberta, Report by BEAK Consultants for Panarctic Oils, Ltd., 67 p.

Carson, C. E., and Hussey, K. M., 1962, The oriented lakes of Arctic Alaska: Journal of Geology, v. 70, p. 417-439.

Challinor, J. L., 1970, Vehicle perturbation effects upon a tundra soil-plant system: Berkeley, California, University of California unpublished M.S. thesis, 240 p.

Chance, N. A., 1966, The Eskimo of north Alaska: New York, New York, Holt, Rinehart and Winston, Publishers.

Chapman, R. C., 1977, The effects of human disturbance on wolves (Canus lupus): Fairbanks, Alaska, University of Alaska unpublished M.S. thesis, 209 p.

Childers, J. M., Sloan, C. E., Meckel, J. P., and Nauman, J. W., 1977, Hydrologic reconnaissance of the eastern North Slope, Alaska, 1975: U.S. Geological Survey Open-File Report 77-492, 65 p.

Clebsch, E. E. C., and Shanks, R. E., 1968, Summer climatic gradients and vegetation near Barrow, Alaska: Arctic, v. 21, p. 161-171.

Conover, J. H., 1960, Macro- and micro-climate of the Arctic Slope of Alaska: Natick, Massachusetts, Quartermaster Research and Engineering Center Technical Report EP-189, 65 p.

Cook, J. P., editor, 1970, Report of archaeological survey and excavations along the Alyeska Pipeline Service Company haul road and pipeline alignments: College, Alaska.

Cowardin, L. M., and Carter, V., 1977, Classification of wetlands and deep-water habitats of the United States (an operational draft): U.S. Fish and Wildlife Service, 100 p.

Craig, P. C., and McCart, P. J., 1974, Fall spawning and overwintering areas of fish populations along routes of proposed pipeline between Prudhoe Bay and Mackenzie Delta, 1972-73: Canadian Arctic Gas Study, Ltd./Alaskan Arctic Gas Study Co., Biology Report Series, v. 15, no. 3, 36 p.

Curatolo, J. A., and Moore, G. D., 1975, Home range and population dynamics of grizzly bears (Ursus arctos L.) in the eastern Brooks Range, Alaska, Chapter 1, in R. D. Jakimchuk, editor, Studies of large mammals along the proposed MacKenzie Valley gas pipeline route from Alaska to British Columbia: Alaskan Arctic Gas Biology Report Series No. 32, 57 p. and appendix.

Curatolo, J. A., and Roseneau, D. G., 1977, The distribution and movements of the Porcupine Caribou Herd in northeastern Alaska and the Yukon Territory, 1976: Renewable Resource Consulting Services, Ltd., unpublished report, 59 p.

Dauphine, T. C., Jr., 1976, Biology of the Kaminuriak population of barren-ground caribou; Part 4, Growth, reproduction, and energy reserves: Canadian Wildlife Service Report Series No. 38, 69 p.

Davis, J. L., and Valkenburg, P., 1979, Caribou distribution, population characteristics, mortality, and responses to disturbance in northwest Alaska, in Studies of selected wildlife and fish and their use of habitats on and adjacent to the National Petroleum Reserve in Alaska, 1977-1978: Anchorage, Alaska, U.S. Department of the Interior, National Petroleum Reserve in Alaska 105(c) Land Use Study, v. 1, p. 13-52.

Davis, R. A., and Wiseley, A. N., 1974, Normal behavior of snow geese on the Yukon-Alaska North Slope and effects of aircraft-induced disturbance on this behavior: Alaskan Arctic Gas Biology Report Series, v. 27, no. 2, 85 p.

Dekin, A., 1973, The Arctic, in J. A. Fitting, editor, The development of North American archaeology: New York, New York, Anchor Books, p. 15-48.

DeMaster, D. P., and Stirling, I., 1981, Ursus maritimus: American Society of Mammalogists, Mammalian Species Series No. 45, 7 p.

Derksen, D. V., Eldridge, W. D., and Rothe, T. C., 1979, Waterbird and wetland habitat studies, in Studies of selected wildlife and fish and their use of habitats on and adjacent to the National Petroleum Reserve in Alaska, 1977-1978: Anchorage, Alaska, U.S. Department of the Interior, National Petroleum Reserve in Alaska 105(c) Land Use Study, Field Study 3, v. 2, p. 229-312.

Derksen, D. V., Rothe, T. C., Eldridge, W. D., 1981, Use of wetland habitats by birds in the National Petroleum Reserve-Alaska: Washington, D.C., U.S. Fish and Wildlife Service, Resource Publication 141.

Divoky, G. J., 1978, The distribution, abundance, and feeding ecology of birds associated with pack ice, in Annual Report of Principal Investigators, 1978: Boulder, Colorado, U.S. Bureau of Land Management Outer Continental Shelf Environmental Assessment Program, v. 2, p. 167-509.

Drew, J. V., 1957, A pedologic study of Arctic Coastal Plain soils near Point Barrow, Alaska: New Jersey, Rutgers University unpublished Ph. D. thesis.

Drew, J. V., and Tedrow, J. C. F., 1957, Pedology of an Arctic brown profile near Point Barrow, Alaska: Soil Science Society of America, Proceedings, v. 21, p. 336-339.

_____1962, Arctic soil classification and patterned ground: Arctic, v. 15, p. 109-116.

Emmel, K. S., compiler, 1982, Geological literature on the North Slope of Alaska, 1974-80: Anchorage, Alaska, Alaska Department of Natural Resources, Division of Geological and Geophysical Surveys, 127 p.

Everett, K. R., 1967, Mass-wasting in the Tasersiaq area, west Greenland: Meddelelser om Gronland, v. 165, 32 p.

_____1980a, Soils, p. 20-23, in D. A. Walker, K. A. Everett, P. J. Webber, and Jerry Brown, 1980, Geobotanical atlas of the Prudhoe Bay region, Alaska: Hanover, New Hampshire, U.S. Army Cold Regions Research and Engineering Laboratory, CRREL Report 80-14, 69 p.

_____1980b, Landforms, in D. A. Walker, K. A. Everett, P. J. Webber, and Jerry Brown, 1980, Geobotanical atlas of the Prudhoe Bay region, Alaska: Hanover, New Hampshire, U.S. Army Cold Regions Research and Engineering Laboratory, CRREL Report 80-14, 69 p.

_____1981a, Soil-landscape relations at selected sites along environmental gradients in northern Alaska: Research Triangle Park, North Carolina, Final report to U.S. Army Research Office, Contract No. DAAG29-79-C-0160, 357 p.

_____1981b, Inigok ice road--Reevaluation of disturbance, 1981: Hanover, New Hampshire, Unpublished report to U.S. Army Cold Regions Research and Engineering Laboratory, 14 p.

Everett, K. R., and Parkinson, R. J., 1977, Soil and landform associations, Prudhoe Bay area, Alaska: Arctic and Alpine Research, v. 9, p. 1-19.

Fay, F. H., 1974, The role of ice in the ecology of marine mammals of the Bering Sea, in D. W. Wood and E. J. Kelley, editors, Oceanography of the Bering Sea: Fairbanks, Alaska, University of Alaska, Institute of Marine Science.

Ferrians, O. J., Jr., 1965, Permafrost map of Alaska: U.S. Geological Survey Miscellaneous Investigations Map I-445, scale 1:2,500,000.

Ferrians, O. J., Jr., Kachadoorian, Reuben, and Greene, G. W., 1969, Permafrost and related engineering problems in Alaska: U.S. Geological Survey Professional Paper 678, 37 p.

Fosberg, F. R., 1970, A classification of vegetation for general purposes, in G. F. Peterken, editor, Guide to the check sheet for IBP areas (2d printing): Oxford, England, Blackwell Scientific Publications, IBP Handbook No. 4.

Fraker, M. A., 1979, Spring migration of bowhead (Balaena mysticetus) and white whales (Delphinapterus leucas) in the Beaufort Sea: Canadian Department of Fisheries and Environment, Fisheries and Marine Service, 36 p.

Fraker, M. A., Green, C. R., and Wursig, B., 1981, Disturbance responses of bowheads and characteristics of waterborne noise, p. 91-195, in W. J. Richardson, editor, Behavior, disturbance responses and feeding of bowhead whales in the Beaufort Sea, 1981: Bryan Texas, Unpublished report by L. G. L. Ecological Research Associates, Inc., for U.S. Bureau of Land Management, 273 p.

Fraker, M. A., Sergeant, D. E., and Hoek, W., 1978, Bowhead and white whales in the southern Beaufort Sea: Beaufort Sea Project, Technical Report No. 4, 114 p.

Franklin, Sir J., 1828, Narrative of the second expedition to the shores of the polar sea in the years 1825-1827: London, England, J. Murray Company.

Franzmann, A. W., 1978, Moose, p. 67-81, in J. L. Schmidt and D. L. Gilbert, editors, Big game of North America--Ecology and management: Harrisburg, Pennsylvania, Stockpole Books, 494 p.

Gavin, A., 1980, Wildlife of the North Slope--A 10-year study, 1969-1978: Atlantic Richfield Company, 46 p.

Gaydos, Leonard, and Newland, W., 1978, Inventory of land use and landcover of the Puget Sound region using Landsat digital data: U.S. Geological Survey Journal of Research, v. 6, no. 6, p. 807-814.

Geraci, J. R., and Smith, T. G., 1976, Direct and indirect effects of oil on ringed seals (Phoca hispida) of the Beaufort Sea, Fisheries Resources Board of Canada, v. 33, p. 1976-1984.

Gersper, P. L., Alexander, V., Barkley, S. A., Barsdate, R. J., and Flint, P. S., 1980, The soils and their nutrients, in Jerry Brown, editor, An arctic ecosystem--The coastal tundra at Barrow, Alaska: Stroudsburg, Pennsylvania, Dowden, Hutchinson and Ross, p. 219-254.

Giddings, J. L., Jr., 1952, The arctic woodland culture of the Kobuk River: Philadelphia, Pennsylvania, University of Pennsylvania Museum Monograph.

_____1954, The tenuous Beaufort Sea archaeology, in Proceedings of the 5th Alaskan Science Conference: Fairbanks, Alaska.

Gollop, J. B., and Sheir, C. E. P., 1978, Status report on Eskimo curlew (Numenius borealis) in Canada: Ottawa, Ontario, Canadian Wildlife Service, 53 p.

Gollop, M. A., and Davis, R. A., 1974, Gas compressor noise simulator disturbance to snow geese, Komakuk Beach, Yukon Territory, September 1972: Alaskan Arctic Gas Biology Report Series, v. 14, no. 8, p. 280-304.

Gollop, M. A., and Richardson, W. J., 1974, Inventory and habitat evaluation of bird breeding and moulting areas along the Beaufort seacoast from Prudhoe Bay, Alaska, to Shingle Point, Yukon Territory, July 1973: Alaskan Arctic Gas Biological Report Series, v. 26, no. 1, 61 p.

Gollop, M. A., Davis, R. A., Prevett, J. P., and Felske, B. E., 1974, Disturbance studies of terrestrial breeding bird populations, Firth River, Yukon Territory, June 1972: Arctic Gas Biology Report Series, v. 14, no. 3, 56 p.

Grace, E. S., 1976, Interactions between men and wolves at an arctic outpost on Ellesmere Island: Canadian Field-Naturalist, v. 90, p. 149-156.

Hall, E. S., Jr., 1981, Cultural resource site potential, in Cultural resources in the mid-Beaufort Sea region: A report for the North Slope Borough's Coastal Zone Management Plan.

Hall, E. S., Jr., and Gal, R., 1982, A summary of the USGS/BLM cultural resource program in the National Petroleum Reserve in Alaska, 1977-1981: Draft submitted to the U.S. Geological Survey in February 1982 for review for publication in the U.S. Geological Survey Professional Paper series.

Haugen, R. K., and Brown, Jerry, 1980, Coastal-inland distributions of summer air temperature and precipitation in northern Alaska: Arctic and Alpine Research, v. 12, p. 403-412.

Haugh, J. R., 1976, Recent history of peregrine falcons in the Tanana Valley, Alaska: State University of New York and Alaska Department of Fish and Game, 15 p.

Hettinger, L. R., and Janz, A. J., 1974, Vegetation and soils of northeastern Alaska: Northern Engineering Services Company, Limited, for Canadian Arctic Gas Study, Limited, Arctic Gas Study Company, Alaskan Arctic Gas Biological Report Series, v. 21, 206 p.

Hoffman, W. A., 1974, Observations on the influence of seismic activity on wintering caribou in the Fish River area, Northwest Territories: Game Management Report.

Hogan, A. W., 1970, Snowmelt delay by oversnow vehicles: Water Resources Research, v. 8, no. 1, p. 174-175.

Hok, J. R., 1969, A reconnaissance of tractor trails and related phenomena on the North Slope of Alaska: U.S. Department of the Interior, Bureau of Land Management Report, 66 p.

Holowaychuk, N., Petro, J. H., Pinney, H. R., Farnham, R. S., and Gersper, P. L., 1966, Soils of Ogotoruk Creek watershed, in N. J. Wilimovsky and J. N. Wolfe, editors, Environment of the Cape Thompson region, Alaska: U.S. Atomic Energy Commission, PNE-481, Chapter 13, p. 221-273.

Hopkins, D. M., 1949, Thaw lakes and thaw sinks in the Imuruk Lake area, Seward Peninsula, Alaska: Journal of Geology, v. 57, p. 119-131.

Hopkins, D. M., and Hartz, R. W., 1978, Coastal morphology, coastal erosion and barrier islands of the Beaufort Sea, Alaska: U.S. Geological Survey Open-File Report 78-1063, 54 p.

Hopkins, D. M., and Sigafoos, R. A., 1951, Frost action and vegetation patterns on Seward Peninsula, Alaska: U.S. Geological Survey Bulletin 974-C, p. 51-100.

Hulten, Eric, 1968, Flora of Alaska and neighboring territories: Stanford, California, Stanford University Press, 1,008 p.

Institute of Social and Economic Research, 1981, Energy development and the North Slope Inupiat--Quantitative analysis of social and economic change: Anchorage, Alaska, University of Alaska, Man in the Arctic Program, 132 p.

Irving, W. N., 1971, Recent early man research in the North: Arctic Anthropology, v. 8, no. 2, p. 68-82.

Jacobsen, J. O., 1974, Potential impact of the Mackenzie Gas Pipeline on bird populations in the Yukon and Northwest Territories, in Environmental Impact Assessment: v. IV.

Jacobson, M. J., 1979, Utilization of the Porcupine Caribou Herd at Kaktovik: Fairbanks, Alaska, U.S. Fish and Wildlife Service, Arctic National Wildlife Refuge, unpublished report, 60 p.

_____1980, Grizzly bear management plan, William O. Douglas Arctic Wildlife Range: Fairbanks, Alaska, U.S. Fish and Wildlife Service, unpublished draft, 23 p.

_____1982, Kaktovik subsistence--Land use values through times in the Arctic National Wildlife Refuge area: U.S. Fish and Wildlife Service Technical Report. (In press.)

Jacobson, M. J., and Wentworth, Cynthia, 1982, Qaakugvigmiut subsistence--Land use values through time in northeast Alaska: Fairbanks, Alaska, U.S Fish and Wildlife Technical Report.

Jefferies, R. L., 1977, The vegetation of salt marshes at some coastal sites in Arctic North America: Journal of Ecology, v. 65, p. 661-672.

Jeness, D., 1928, Archaeological investigations in the Bering Strait, 1926: Annual Report to the National Museum of Canada for 1926, National Museum of Canada Bulletin 50, p. 71-81.

Jonkel, Charles, 1978, Black, brown (grizzly), and polar bears, p. 227-248, in J. L. Schmidt and D. L. Gilbert, editors, Big game of North America--Ecology and management: Harrisburg, Pennsylvania, Stockpole Books, 494 p.

Kevan, P. G., 1971, Vehicle tracks on high arctic tundra--An 11-year case history around Hazen Camp, Ellesmere Island, Northwest Territories: Ottawa, Canada, Defense Research Board of Canada Report, Hazen 41, 70 p.

Klein, D. R., 1973, The impact of oil development in the northern environment: Proceedings of the Interpetrol Congress, v. 3, p. 109-121.

_____1980, Reaction of caribou and reindeer to obstructions--A reassessment, p. 519-527, in E. Reimers, E. Garre, and S. Skjenneberg, editors, Proceedings of the 2d International Reindeer/Caribou Symposium, Røros, Norway, 1979: 799 p.

Koppejan, A. W., van Wanelen, B. M., and Weinberg, L. J. H., 1948, Coastal flow slides in the Dutch province of Zeeland: Rotterdam, Netherlands, International Conference on Soil Mechanics and Foundation Engineering, 2d, 1948?, Proceedings, 5, p. 89-96.

Kovacs, A., and Mellor, M., 1974, Sea ice morphology and ice as a geologic agent in the southern Beaufort Sea, in J. C. Reed and J. E. Sater, editors, The coast and shelf of the Beaufort Sea: Arlington, Virginia, Arctic Institute of North America, 750 p.

Kuchler, A. W., 1967, Vegetation mapping: New York, New York, Ronald Press.

Lachenbruch, A. H., 1962, Mechanics of thermal contraction cracks and ice-wedge polygons in permafrost: Geological Society of America Special Paper 70, 69 p.

Lambert, J. D. H., 1972, Botanical changes resulting from seismic and drilling operations, Mackenzie Delta area: Ottawa, Ontario, Northern Economic Development Branch, DIAND, ALUR Report No. 71-71-12, 70 p.

Lawson, D. E., Brown, Jerry, Everett, K. R., Johnson, A. W., Komarkova, V., Murray, B. M., Murray, D. F., and Webber, P. J., 1978, Tundra disturbances and recovery following the 1949 exploratory drilling, Fish Creek, northern Alaska: Hanover, New Hampshire, U.S. Army Cold Regions Research and Engineering Laboratory, CRREL Report 78-28, 91 p.

Leffingwell, E. de K., 1915, Ground ice-wedges--The dominant form of ground ice on the north coast of Alaska: Journal of Geology, v. 23, p. 635-654.

_____1919, The Canning River region: U.S. Geological Survey Professional Paper 109, 251 p.

Lent, P. C., 1976, Impact on the living environment: Transcripts of the Mackenzie Valley Pipeline Inquiry, v. 106, p. 16245.

_____1978, Musk-ox, p. 135-147, in J. L. Schmidt and D. L. Gilbert, editors, Big game of North America--Ecology and management: Harrisburg, Pennsylvania, Stockpole Books, 494 p.

Lentfer, J. W., 1971, The effects of ocean currents and ice movement on polar bear activity: Federal Aid Wildlife Restoration Projects W-17-2 and W-17-3, Job 5.2R, 11 p.

_____1974a, Polar bear reproduction biology and denning: Final report, Federal Aid in Wildlife Restoration Projects W-17-3 and W-17-4, Job VB-5.4, 32 p.

_____1974b, Polar bears and the Alaskan Arctic gas pipeline coastal route proposal: Memorandum to A. J. Seidl, Alaska Gas Corridor Planning Team.

Lentfer, J. W., and Hensel, R. J., 1980, Alaskan polar bear denning, in C. J. Martinka and K. L. McArthur, editors, Bears--Their biology and management: Washington, D.C., U.S. Government Printing Office, p. 101-109.

Lewellen, R. I., 1970, Permafrost erosion along the Beaufort Sea coast: Denver, Colorado, published by the author.

_____1977, A study of Beaufort Sea coastal erosion, northern Alaska, in Environmental assessment of the Alaskan Continental Shelf: National Oceanic and Atmospheric Administration-Bureau of Land Management Outer Continental Shelf Environmental Assessment Program, v. XV, p. 493-519.

Lewis, C. R., 1959, Geology of Barter Island and the Alaska arctic coast, p. 61-83, in Military Geology Branch, U.S. Geological Survey, Preliminary report of the Mount Chamberlin-Barter Island Project, Alaska, 1958: Bedford, Massachusetts, Progress report for Air Force Cambridge Research Center, 83 p.

Ljungblad, D. K., Platter-Rieger, M. F., and Shipp, F. S., Jr., 1980, Aerial surveys of bowhead whales, North Slope, Alaska: Naval Ocean Systems Center, Technical Document 314, 181 p.

Lowry, L. F., and Burns, J. J., 1980, Foods utilized by bowhead whales near Barter Island, Alaska, autumn, 1979: Marine Fisheries Review, September-October 1980, p. 88-91.

Lowry, L. F., Frost, K. J., and Burns, J. J., 1978, Food of ringed seals and bowhead whales near Point Barrow, Alaska: Canadian Field-Naturalist, v. 92, p. 67-70.

_____1979, Trophic relationships among ice inhabiting phocid seals and functionally related marine mammals, in Environmental assessment of the Outer Continental Shelf: Final report of Principal Investigators, v. 6, Biological Studies, p.573-629.

_____1981, Trophic relationships among ice inhabiting phocid seals and functionally related marine mammals: Outer Continental Shelf Environmental Assessment Program, Research Unit No. 232, 40 p.

Lyon, J. G., and George, T. L., 1979, Vegetation mapping in the Gates of the Arctic National Park: Presented at the 45th Annual Meeting of the American Society of Photogrammetry, Washington, D.C., March 22, 1979, and published in the proceedings, p. 483-497.

Machida, S., and Oldemeyer, J. L., 1980, Caribou habitat use dynamics on the calving grounds of the William O. Douglas National Wildlife Refuge: Unpublished report, 24 p.

McCourt, K. H., Feist, J. D., Doll, D., and Russell, J. J., 1974, Disturbance studies of caribou and other mammals in the Yukon and Alaska, 1972: Alaskan Arctic Gas Biology Report Series, v. 5, 246 p.

Mackay, J. R., 1963, The Mackenzie Delta area, Northwest Territory: Geographical Branch, Mines and Technical Surveys Memoir 8, 202 p.

McKee, J. E., and Wolf, H. W., 1973, Water quality criteria, 2d edition: State of California, Water Control Board, 548 p.

MacNeish, R. S., 1956, The Engigstciak site on the Yukon Arctic coast: University of Alaska Anthropology Papers, v. 4, p. 91-111.

McLaren, I. A., 1958, The biology of the ringed seal (Phoca hispida Schreber) in the eastern Canadian Arctic: Fisheries Resources Board of Canada Bulletin 118, 97 p.

Maher, J. C., and Trollman, W. M., 1970, Geological literature on the North Slope of Alaska: Tulsa, Oklahoma, American Association of Petroleum Geologists, 133 p.

Marquette, W. M., 1977, The 1976 catch of bowhead whales (Balaena mysticetus) by Alaskan Eskimos, with a review of the fishery, 1973-1976, and a biological summary of the species: National Oceanic and Atmospheric Administration, National Marine Mammal Laboratory and National Marine Fisheries Service, Processed Report, 96 p.

Marquette, W. M., Nerini, M. K., Braham, H. W., and Miller, R. V., 1981, Bowhead whale studies, autumn 1980-spring 1981--Harvest, biology, and distribution: National Oceanic and Atmospheric Administration, National Marine Mammal Laboratory and National Marine Fisheries Service, Processed Report, 27 p.

Martin, D. F., and Moitoret, C. S., 1981, Bird populations and habitat use, Canning River Delta, Alaska: Fairbanks, Alaska, U.S. Fish and Wildlife Service unpublished report.

Mast, R. F., McMullin, R. H., Bird, K. J., and Prosge, W. P., 1980, Resource appraisal of undiscovered oil and gas resources in the William O. Douglas Arctic Wildlife Range: U.S. Geological Survey Open-File Report 80-916, 54 p.

Mech, L. D., 1970, The wolf--The ecology and behavior of an endangered species: New York, New York, Natural History Press, 384 p.

Meyers, C. R., 1981, Provisional checklist to the vascular flora of the Beaufort Lagoon coastal environment, Arctic National Wildlife Refuge: Fairbanks Alaska, University of Alaska Museum, 7 p.

Miller, F. L., and Gunn, A., 1979, Responses of peary caribou and muskoxen to helicopter harrassment, Prince of Wales Island, Northwest Territories, 1976-77: Canadian Wildlife Service Occasional Paper No. 40, 99 p.

Miller, P. C., 1981, Carbon dioxide effects research and assessment program--Carbon balance in northern ecosystems and the potential effect of carbon dioxide-induced climatic change: San Diego, California, Workshop Report, March 7-9, 1980, Department of Energy, Conference 800318, 109 p.

Mitchell, E. D., 1977, Initial population size of bowhead whale (Balaena mysticetus) stocks: Canberra, Australia, Unpublished report submitted to International Whaling Commission Scientific Committee, SC/29/Doc. 33.

Moore, G. D., and Quimby, R., 1974, Environmental considerations for the polar bear (Ursus maritimus Phipps) of the Beaufort Sea, Chapter 2, in R. D. Jakimchuk, editor, Studies of large mammals along the proposed Mackenzie Valley gas pipeline route from Alaska to British Columbia: Alaskan Arctic Gas Biology Report Series, v. 32.

Morrissey, L. A., and Ennis, R. A., 1981, Vegetation mapping of the National Petroleum Reserve in Alaska using Landsat digital data: U.S. Geological Survey Open-File Report 81-315.

Mould, E. D., 1977, Movement patterns of moose in the Colville River area, Alaska: Fairbanks, Alaska, University of Alaska unpublished M.S. thesis, 82 p.

Muller, S. W., 1943, Permafrost or permanently frozen ground and related engineering problems: U.S. Geological Survey Special Report, Strategic Engineering Study 62, 2d edition, Military Intelligence Division, Office, Chief of Engineers, U.S. Army, 231 p. (Also lithoprinted by Edwards Brothers, Ann Arbor, Michigan, 1947.)

Murdock, John, 1885, Bird migration at Point Barrow, Arctic Alaska: Auk, v. 2, 63 p.

Murie, 1944, The wolves of Mount McKinley: Fauna National Parks U.S., Fauna Series No. 5, 238 p.

Murray, D. F., 1979, Balsam poplar in Arctic Alaska: Canadian Journal of Anthropology, p. 29-32.

_____1980, Threatened and endangered plants of Alaska: Anchorage, Alaska, U.S. Forest Service and Bureau of Land Management, 59 p.

Murray, D. F., Murray, B. M., and Johnson, A. W., 1977, Botanical reconnaissance of the Yukon River-Prudhoe Bay haul road: Hanover, New Hampshire, U.S. Army Cold Regions Research and Engineering Laboratory, CRREL Internal Report 511, 134 p.

Myers, J. P., and Pitelka, F. A., 1979, Variations in summer temperature patterns near Barrow, Alaska--Analysis and ecological interpretation: Arctic and Alpine Research, v. 11, p. 131-144.

Namtvedt, T., Parrish, S., Friese, N., and Quirk, W., 1974, The Alaskan arctic coast--A background study of available knowledge: Anchorage, Alaska, Arctic Institute of North America and U.S. Army Corps of Engineers, 551 p.

Naval Arctic Research Laboratory, 1980, Investigation of the occurrence and behavior patterns of whales in the vicinity of the Beaufort Sea lease area: Anchorage, Alaska, Alaska Outer Continental Shelf Office, Final report for the period October 1, 1978, through November 30, 1979: Prepared for the U.S. Bureau of Land Management, 753 p.

Nelson, E. W., 1898, Notes on the wild fowl and game animals of Alaska: National Geographic Magazine, no. 9, p. 121-132.

Nodler, F. A., and LaPerriere, A. J., 1977, Landsat mapping--North Slope, Arctic National Wildlife Refuge: Fairbanks, Alaska, mimeo reprint on file with the U.S Fish and Wildlife Service, Arctic National Wildlife Refuge Headquarters, 16 p.

Nodler, F. A., LaPerriere, A. J., and Klein, D. R., 1978, Vegetation type mapping in northwestern Alaska in relation to caribou and reindeer range potentials: Fairbanks, Alaska, University of Alaska, Alaska Cooperative Wildlife Research Unit, Special Report No. 2, 33 p.

North Slope Borough Assembly, 1978, A resolution of the assembly of the North Slope Borough opposing oil development in the calving area of the Porcupine Caribou Herd: Barrow, Alaska, August 1, Resolution No. 19-78, 2 p.

_____1980, Kaktovik capital improvement program: Aerial photograph and map, July 13, 1979, and September 26, 1979.

_____1981, Annual overall economic development program report: Overall Economic Development Program Committee, 25 p.

Office of the Federal Inspector, 1980, Biological assessment of the endangered peregrine falcon (Falco peregrinus tundrius, Falco peregrinus anatum): Anchorage, Alaska, Report submitted to the U.S. Fish and Wildlife Service, 80 p.

Oldemeyer, J. L., and others, 1978, Caribou habitat studies on the Arctic National Wildlife Refuge: Fairbanks, Alaska, Unpublished report on file at the U.S. Fish and Wildlife Service, 28 p.

Parkinson, R. J., 1978, Genesis and classification of Arctic Coastal Plain soils, Prudhoe Bay, Alaska: Columbus, Ohio, Ohio State University, Institute of Polar Studies, Report No. 68, 147 p.

Patterson, L. A., 1974, An assessment of the energetic importance of the North Slope to snow geese (Chen caerulescens) during the staging period in September, 1973: Alaskan Arctic Gas Biology Report Series, v. 27, no. 4, p. 1-67.

Platt, J. B., and Tull, C. E., 1977, A study of wintering and nesting gyrfalcons on the Yukon North Slope during 1975, with emphasis on their behavior during experimental overflights by helicopters: Alaskan Arctic Gas Biology Report Series, v. 35, no. 1, p. 1-90.

Quimby, R., 1974, Grizzly bear, Chapter 2, in R. D. Jakimchuk, editor, Mammal studies in northeastern Alaska, with emphasis within the Canning River drainage: Alaskan Arctic Gas Biology Report Series No. 24, 85 p. and appendix.

Quimby, R., and Snarski, D. J., 1974, A study of fur-bearing animals associated with gas pipeline routes in Alaska, Chapter 2, in R. D. Jakimchuk, editor, Mammal studies in northeastern Alaska, with emphasis within the Canning River drainage: Alaskan Arctic Gas Biology Report Series No. 6, 101 p. and appendix.

Racine, C. H., 1980, Effects of a tundra fire on soils and plant communities along a hillslope in the Seward Peninsula, Alaska: Hanover, New Hampshire, U.S. Army Cold Regions Research and Engineering Laboratory, CRREL Special Report 80-37, 21 p.

_____1981, Tundra fire effects on soils and three plant communities along a hillslope gradient in the Seward Peninsula, Alaska: Arctic, v. 34, p. 71-84.

Racine, C. H., and Anderson, J. H., 1979, Flora and vegetation of the Chukchi-Imuruk Lake area, Alaska, in H. R. Melchior, editor, Biological survey of the Bering Land Bridge National Monument: Report to the National Park Service, Contract No. CX-9000-3-031b, p. 38-113.

Radforth, J. R., 1972, Analysis of disturbance effects of operations of off-road vehicles on tundra: Ottawa, Ontario, Northern Economic Development Branch, DIAND, ALUR Report No. 71-72-13, 77 p.

_____1973a, Immediate effects of wheeled vehicle traffic on tundra during the summer: Ottawa, Ontario, Northern Economic Development Branch, DIAND, ALUR Report No. 72-73-12, 32 p.

_____1973b, Long-term effects of summer traffic by tracked vehicles on tundra: Ottawa, Ontario, Northern Economic Development Branch, DIAND, ALUR Report No. 72-73-13, 60 p.

Radforth, J. R., Korpijaakko, E., and Radforth, N. W., 1971, Rut damage on organic terrain, p. 21-26, in J. Curran, editor, Proceedings of the Fourteenth Muskeg Research Conference, 10 and 11 May 1971: NRCC Technical Memoir No. 102, 184 p. (1972).

Rahn, K. A., and McCaffrey, R. J., 1980, On the origin and transport of the winter Arctic aerosol: Annals of the New York Academy of Sciences, v. 338, p. 486-503.

Rausch, R. A., and Pearson, A. M., 1972, Notes on the wolverine in Alaska and the Yukon Territory: Journal of Wildlife Management, v. 36, p. 249-268.

Reiser, H. N., Brosge, W. P., Dutro, J. T., Jr., and Detterman, R. L., 1971, Preliminary geologic map, Mount Michelson quadrangle, Alaska: U.S. Geological Survey Open-File Map, 2 sheets, scale 1:250,000.

_____1980, Geologic map of the Demarcation Point quadrangle, Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-1133, scale 1:250,000.

Reynolds, H. V., 1979, Population, biology, movements, distribution and habitat utilization of a grizzly bear population in NPR-A, Chapter 5, in Studies of selected wildlife and fish and their use of habitats on and adjacent to the National Petroleum Reserve in Alaska, 1977-78: U.S. Department of the Interior, NPR-A Work Group 3, p. 129-182.

Reynolds, P. C., 1981, Some effects of oil and gas exploration activities on tundra vegetation in northern Alaska: Fairbanks, Alaska, Unpublished manuscript on file with the Bureau of Land Management, 15 p.

Reynolds, P. C., Follmann, E., and Reynolds, H. V., 1982, Some effects of seismic activities on denning grizzly bears in northern Alaska: U.S. Department of the Interior. (In press.)

Ricciardelli, A. F., 1954, Archaeological survey of Kongakut Firth River area, in W. G. Carnes, editor, A preliminary geographical survey of the Kongakut Firth River area: Report prepared for the National Park Service.

Richardson, W. J., and Fraker, M. A., 1981, Project rationale and design, p. 1-20, in W. J. Richardson, editor, Behavior, disturbance responses and feeding of bowhead whales in the Beaufort Sea, 1980: Bryan Texas, Unpublished report by L. G. L. Ecological Research Associates, Inc., for U.S. Bureau of Land Management, 273 p.

Rickard, W. E., and Brown, Jerry, 1974, Effects of vehicles on arctic tundra: Environmental Conservation (Switzerland), v. 1, p. 55-62.

Rieger, S., Schoephorster, D. B., and Furbush, C. E., 1979, Exploratory soil survey of Alaska: U.S. Department of Agriculture, Soil Conservation Service, 213 p.

Robus, M. A., 1981, Muskox habitat and use patterns in northeastern Alaska: Fairbanks, Alaska, University of Alaska unpublished M.S. thesis.

Roseneau, D. G., 1974, A continuation of studies of raptorial bird nesting sites along proposed pipeline routes in Alaska: Calgary, Alberta, Unpublished report submitted to Northern Engineering Services Company, Ltd., and Canadian Arctic Gas Study Company, Ltd., 68 p.

Roseneau, D. G., Bente, P. J., and Springer, A. M., 1980, Numbers and status of peregrine falcons (Falco peregrinus) on the Middle Yukon River, Lower Yukon River, and selected areas of the Arctic National Wildlife Range, Alaska, 1980: Anchorage, Alaska, Unpublished report submitted to the U.S. Fish and Wildlife Service, Contract No. 14-16-0007-80-5047, 54 p.

Roseneau, D. G., and Curatolo, J. A., 1976, The distribution and movements of the Porcupine Caribou Herd in northeastern Alaska and the Yukon Territory, 1975, in R. D. Jakimchuk, editor, Studies of mammals along the proposed Mackenzie Valley Gas Pipeline route, 1975: Alaskan Arctic Gas Biology Report Series, v. 36.

Roseneau, D. G., Reynolds, Harry, III, and White, C. M., 1976, Northeastern Alaska, p. 243-245, in R. W. Fyfe, S. A. Temple, and T. J. Cade, editors, The 1975 North American peregrine falcon survey: Canadian Field-Naturalist, v. 90, no. 3, p. 228-273.

Roseneau, D. G., Tull, C. E., and Nelson, R. W., 1981, Protection strategies for peregrine falcon and other raptors along the planned Northwest Alaskan gas pipeline route: Fairbanks, Alaska, LGL Alaska Resources Association, Northwest, Inc., unpublished report, 2 v., 332 p.

Russell, J., 1977, Some overt responses of muskox and caribou to seismic activities, northeastern Banks Island, March and April 1977: Yellow Knife, Northwest Territories, 65 p.

Ruttan, R. A., 1974, Observations of moose in the northern Yukon Territory and Mackenzie River valley, 1972, in R. A. Ruttan and D. R. Wooley, editors, Studies of furbearers associated with proposed pipeline routes in the Yukon and Northwest Territories: Canadian Arctic Gas Study, Ltd./Alaskan Arctic Gas Study Biology Report Series, v. 9, chapter 6, 45 p.

Salter, R., and Davis, R. A., 1974, Surveys of terrestrial bird populations in Alaska, Yukon Territory, Northwest Territories, and northern Alberta, May, June, July 1972: Alaskan Arctic Gas Biology Report Series, v. 12, no. 2, p. 1-349.

Schallock, E. W., 1976, Implications of resource development on the North Slope of Alaska with regard to water quality on the Sagavanirktok River, in Proceedings of an EPA-sponsored Symposium on Marine, Estuarine, and Freshwater Quality, 26th Annual Meeting, American Institute of Biological Scientists, 1975: U.S Environmental Protection Agency Report EPA-600/3-76--079, p. 174-184.

Schweinsburg, R. E., 1974, An ornithological study of proposed gas pipeline routes in Alaska, Yukon Territory, and the Northwest Territories, 1971: Alaskan Arctic Gas Biology Report Series, v. 10, 215 p.

Schweinsburg, R. E., Gollop, M. A., and Davis, R. A., 1974, Preliminary waterfowl disturbance studies, Mackenzie Valley, August 1972: Alaskan Arctic Gas Biology Report Series, v. 14, no. 6, p. 232-259.

Searby, H. W., 1968, Climates of the States--Alaska, in Climatography of the United States: U.S. Department of Commerce, Environmental Sciences Administration, Environmental Data Service.

Selkregg, L. L., 1975, Alaska regional profiles--Arctic region: Anchorage, Alaska, University of Alaska, Arctic Environmental Information and Data Center, 218 p.

Sergeant, D. E., and Hoek, W., 1974, Seasonal distribution of bowhead and white whales in the eastern Beaufort Sea, in J. C. Reed and J. E. Sater, editors, The coast and shelf of the Beaufort Sea, Proceedings of a symposium on Beaufort Sea--Coast and Shelf Research: Arlington, Virginia, Arctic Institute of North America, p. 705-720.

Sigafoos, R. S., 1952, Frost action as a primary physical factor in tundra plant communities: Ecology, v. 33, p. 480-487.

Sloan, C. E., Trabant, Dennis, and Glude, William, 1979, Reconnaissance snow surveys of the National Petroleum Reserve in Alaska, April 1977 and April-May 1978: U.S. Geological Survey Water-Resources Investigations Open-File Report 79-1342, 31 p.

Smith, T. G., Distribution and abundance of Dall sheep in the Arctic National Wildlife Range: Fairbanks, Alaska, U.S. Fish and Wildlife Service, xerographic report on file, 12 p.

Smith, T. G., and Geraci, J. R., 1975, Effect of contact and ingestion of crude oil on ringed seals of the Beaufort Sea: Beaufort Sea Project Technical Report 5, 67 p.

Smith, T. G., and Stirling, I., 1975, The breeding habitat of the ringed seal (Phoca hispida)--The birth lair and associated structures: Canadian Journal of Zoology, v. 53, no. 9, p. 1297-1305.

Sohio Petroleum Company, 1981, Prudhoe Bay oil field geobotanical master map: Scale 1:6,000, 23 map sheets.

Soil Survey Staff, 1975. See U.S. Department of Agriculture.

Solecki, R. S., 1951, Archaeology and ecology of the Arctic Slope of Alaska: Annual report of the Board of Regents of the Smithsonian Institution for 1950, p. 469-495.

Solecki, R. S., Salwen, B., and Jacobsen, J., 1973, Archaeological reconnaissances north of the Brooks Range in northeastern Alaska: The University of Calgary, Department of Archaeology, Occasional Papers No. 1.

Spetzman, L. A., 1959, Vegetation of the Arctic Slope of Alaska--Exploration of Naval Petroleum Reserve No. 4 and adjacent areas, northern Alaska, 1944-53: U.S. Geological Survey Professional Paper 302-B, p. 19-58.

Spindler, M. A., 1978, Bird populations and habitat use in the Okpilak River Delta area, Arctic National Wildlife Range, Alaska: Fairbanks, Alaska, U.S Fish and Wildlife Service, xerographic report on file, 86 p.

Spindler, M. A., and Knudtson, E. P., 1978, Breeding bird populations in the Okpilak River Delta area, Arctic National Wildlife Refuge: Fairbanks, Alaska, Preliminary report on file at the U.S. Fish and Wildlife Service, 5 p.

Starr, S. J., Kuwada, M. N., and Trasky, L. L., 1981, Recommendations for minimizing the impacts of hydro-carbon development on the fish, wildlife, and aquatic plant resources of the Northern Bering Sea and Norton Sound: Alaska Department of Fish and Game, 525 p.

Steere, W. C., and Murray, B., 1976, Andreaebryum macrosporum--A new genus and species of Musci from northern Alaska and Canada: Phytologia, v. 33, p. 407-410.

Stefansson, V., 1914, The Stefansson-Anderson Arctic expedition of the American Museum--Preliminary ethnological report: New York, Anthropological Papers of the American Museum of Natural History, v. 14, part 1.

Stenmark, R. J., and Schoeder, T. H., 1974, Recreation and preservation opportunities--Arctic region resources inventory: Joint Federal-State Land Use Planning Commission, Resource Planning Team, 83 p.

Sterling, T., and Dzubin, A., 1967, Canada goose molt migrations to the Northwest Territories: Transactions of the North American Wildlife and Natural Resources Conference, v. 32, p. 355-373.

Stirling, I., Andriashek, D., Latour, P., and Calvert, W., 1975, Distribution and abundance of polar bears in the eastern Beaufort Sea: Sidney, British Columbia, Institute of Ocean Sciences, Beaufort Sea Project Technical Report 2, 59 p.

Stirling, I., Archibald, R., and DeMaster, D., 1975, The distribution and abundance of seals in the eastern Beaufort Sea, Victoria, Canada: Beaufort Sea Project, Technical Report No. 1, 59 p.

Swain, P. H., 1972, Pattern recognition--A basis for remote sensing data analysis: West Lafayette, Indiana, Purdue University, Purdue University Laboratory for Applications of Remote Sensing Information, Note 111572, 40 p.

Taylor, R. J., 1981, Shoreline vegetation of the Arctic Alaska coast: Arctic, v. 34, p. 37-42.

Tieszen, L. L., 1972, Carbon dioxide exchange in the Alaskan Arctic tundra--Measured cause of photosynthesis: Proceedings of the 1972 Tundra Biome Symposium, p. 29-35.

_____(editor), 1978, Vegetation and production ecology of an Alaskan Arctic tundra: New York, New York, Springer-Verlag, 686 p.

Tillman, M. F., 1980, Introduction--A scientific perspective of the bowhead problem: Marine Fisheries Review, v. 42, nos. 9-10, p. 2-5.

Timm, D., 1979, Relationships between trumpeter swan distribution and cabins in the Susitna Basin, Alaska, in Annual Survey and Inventory Report: Anchorage, Alaska, Alaska Department of Fish and Game, p. 24-29.

Ulrich, A., and Gersper, P., 1978, Plant nutrient limitations of tundra plant growth, in L. L. Teiszen, editor, Vegetation and production ecology of an Alaskan Arctic tundra: New York, New York, Springer-Verlag, p. 457-481.

UNESCO, 1973, International classification and mapping of vegetation: Paris, France, 93 p.

U.S. Bureau of Land Management, 1978, Alaska Outer Continental Shelf Office, Beaufort Sea region socio-economic baseline: Alaska Outer Continental Shelf Socio-Economic Studies Program, Technical Report 11, 636 p.

_____1979, Beaufort Sea draft environmental impact statement, Anchorage, Alaska, Naval Arctic Research Laboratory, Alaska Outer Continental Shelf Office, 270 p.

_____1980, Stipulations: Unpublished attachment to exploration permits, mimeographed report, 8 p.

U.S. Department of Agriculture, 1938, Soils and men: Washington, U.S. Government Printing Office, 1938 USDA Yearbook, 1,232 p.

U.S. Department of Agriculture, Soil Survey Staff, 1975, Soil taxonomy: U.S. Department of Agriculture Handbook 436, 754 p.

U.S. Department of Commerce, 1980, Census of population and housing, Alaska, 1980: Washington, Bureau of Census.

U.S. Department of the Interior, 1979, Final report of the 105(b) economic and policy analysis: Washington, U.S. Government Printing Office, Prepared by the Office of Minerals Policy and Research Analysis, 145 p.

U.S. Fish and Wildlife Service, 1976, National Petroleum Reserve, Alaska, Special areas--Significant wildlife values requiring maximum protection: Anchorage, Alaska, Alaska Area Office, 5 p.

_____1982, Initial report, baseline study of the fish, wildlife, and their habitats, Section 1002(c) of the Alaska National Interest Lands Conservation Act: Anchorage, Alaska, U.S. Fish and Wildlife Service, Region 7, Arctic National Wildlife Refuge Coastal Plain Resource Assessment, 507 p.

U.S. Geological Survey, 1979, An environmental evaluation of potential petroleum development on the National Petroleum Reserve in Alaska: Prepared by the U.S. Geological Survey under Section 105(b) of the Naval Petroleum Reserves Production Act of 1976, 238 p.

University of Alaska, Arctic Environmental Information and Data Center, 1975, Alaska regional profiles, Arctic region, L. L. Selkregg, editor: Anchorage, Alaska, University of Alaska, Arctic Environmental Information and Data Center, 218 p.

Urquhart, D. R., 1973, Oil exploration and Banks Island Wildlife--A guide for the preservation of caribou, muskox, and arctic fox populations on Banks Island, Northwest Territories: 105 p.

Viereck, L. A., and Dyrness, C. T., 1980, A preliminary classification system for vegetation of Alaska: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station, General Technical Report PNW-106, 38 p.

Viereck, L. A., and Little, E. L., Jr., 1972, Alaska trees and shrubs: Washington, D.C., U.S. Department of Agriculture Handbook No. 410, 265 p.

Viereck, L. A., Dyrness, C. T., and Batten, A. R., 1981, Revision of preliminary classification system for vegetation of Alaska: Unpublished manuscript circulated May 28, 1981, 64 p.

Wahrhaftig, Clyde, 1965, Physiographic divisions of Alaska: U.S. Geological Survey Professional Paper 482, 52 p.

Walker, D. A., 1977, The analysis of the effectiveness of a television scanning densitometer for indicating geobotanical features in an ice-wedge polygon complex at Barrow, Alaska: Boulder, Colorado, University of Colorado unpublished M.S. thesis, 129 p. plus 2 maps.

_____1981, The vegetation and environmental gradients of the Prudhoe Bay region, Alaska: Boulder, Colorado, University of Colorado unpublished Ph. D. thesis, 484 p. plus 5 maps.

Walker, D. A., Acevedo, William, and Webber, P. J., 1981, A preliminary landcover classification of the northern portion of the Arctic National Wildlife Refuge, Alaska: Hanover, New Hampshire, Report to the U.S. Army Cold Regions Research and Engineering Laboratory, 61 p.

Walker, D. A., Everett, K. R., Acevedo, William, Webber, P. J., Gaydos, Leonard, and Brown, Jerry, 1982, Geobotanical and Landsat mapping for environmental impact assessment and mitigation--Prudhoe Bay region and Arctic Coastal Plain, Alaska: (In press.)

Walker, D. A., Everett, K. A., Webber, P. J., and Brown, Jerry, 1980, Geobotanical atlas of the Prudhoe Bay region, Alaska: Hanover, New Hampshire, U.S. Army Cold Regions Research and Engineering Laboratory, CRREL Report 80-14, 69 p.

Walker, D. A., Webber, P. J., Everett, K. R., and Brown, Jerry, 1977, The effects of low-pressure wheeled vehicles on plant communities and soils at Prudhoe Bay, Alaska: Hanover, New Hampshire, U.S. Army Cold Regions Research and Engineering Laboratory, CRREL Special Report 77-17, 49 p.

_____ 1978, The effects of crude oil and diesel spills on plant communities at Prudhoe Bay, Alaska, and the derivation of oil spill sensitivity maps: Arctic, v. 31, p. 242-259.

Walker, H. J., 1974, The Colville River and the Beaufort Sea--Some interactions, in J. D. Reed and J. E. Sater, editors, The coast and shelf of the Beaufort Sea: Arlington, Virginia, Arctic Institute of North America, 750 p.

Webber, P. J., and Walker, D. A., 1975, Vegetation and landscape analysis at Prudhoe Bay, Alaska--A vegetation map of the Tundra Biome study area, in Jerry Brown, editor, Ecological investigations of the Tundra Biome in the Prudhoe Bay region, Alaska: Biological Papers of the University of Alaska, Special Report No. 2, p. 81-91.

Weiler, G. J., 1980, Caribou occurrence on Landsat vegetation types on the coastal plain of the Arctic National Wildlife Refuge, May-June 1980: Fairbanks, Alaska, U.S. Fish and Wildlife Service, Arctic National Wildlife Refuge, 36 p.

Welling, C., Johnson, S. R., and Slayden, W. J. L., 1981, A study of lesser snow geese (Chen caerulescens) in the Sagavanirktok River Delta, Alaska: Fairbanks, Alaska, L.G.L. Alaska, 25 p.

Wentworth, C., 1979, Kaktovik synopsis, in Native livelihood and dependence--A study of land use values through time: Anchorage, Alaska, U.S. Department of the Interior, National Petroleum Reserve in Alaska 105(c) Land Use Study, Field Study 1.

White, L. P., 1979, A play approach to hydrocarbon resource assessment and evaluation, in Proceedings of the Conference on the Economics of Exploration for Energy Resource: New York University, May 17-18, 1979.

White, R. G., Bunnell, F. L., Gaare, E., Skogland, T., and Hubert, B., 1981, Ungulates on arctic ranges, chapter 13, in L. C. Bliss, O. W. Heal, and J. J. Moore, editors, Tundra ecosystems: Cambridge, England, Cambridge University Press, IBP No. 25.

Wiggins, I. L., 1951, The distribution of vascular plants on polygonal ground near Point Barrow, Alaska: Palo Alto, California, Stanford University, Dudley Herbarium Contributions, v. 4, no. 3, p. 41-56.

Wiggins, I. L., and Thomas, J. H., 1962, A flora of the Alaskan Arctic Slope: University of Toronto Press, 425 p.

Wilson, C. J., (no date), Report of archaeological survey of the Arctic National Wildlife Refuge: Fairbanks, Alaska, on file with the U.S. Fish and Wildlife Service, Arctic National Wildlife Refuge Headquarters.

Wiseley, A. N., 1974, Disturbance to snow geese and other large waterfowl species by gas compressor sound simulation, Komakuk, Yukon Territory, August-September 1973: Alaskan Arctic Gas Biology Report Series, v. 27, no. 3, p. 1-37.

Wiseman, W. J., Jr., Coleman, J. M., Gregory, A., Hsu, S. A., and others, 1973, Alaska arctic coastal processes and morphology: Louisiana State University Coastal Studies, Institute of Technology Report No. 149, 171 p.

Wiseman, W. J., Jr., Suhayda, J. N., Hsu, S. A., and Walters, C. D., Jr., 1974, Characteristics of nearshore oceanographic environment of arctic Alaska, in J. C. Reed and J. E. Sater, editors, The coast and shelf of the Beaufort Sea: Arlington, Virginia, Arctic Institute of North America, 750 p.

Wissler, C., 1916, Harpoons and darts in the Stefansson collection: Anthropological Papers of the American Museum of Natural History, v. 14, no. 2.

Woodward-Clyde Consultants, 1980, Gravel removal studies in arctic and subarctic flood plains in Alaska, U.S. Fish and Wildlife Service, FWS/OBS-80-08, 403 p.

Woolridge, D. R., and Belton, P., 1980, Natural and synthesized aggressive sounds as polar bear repellants, p. 85-91, in C. J. Martinka and K. L. McArthur, editors, Bears--Their biology and management: Washington, D.C., U.S. Government Printing Office.

Worl, Rosita, 1979, Values of subsistence to North Slope Inupiat culture, in Native livelihood and dependence--A study of land use values through time: Anchorage, Alaska, U.S. Department of the Interior, National Petroleum Reserve in Alaska 105(c) Land Use Study, Field Study 1, p. 17-26.

Wright, J. M., and Fancy, S. G., 1980, The response of birds and caribou to the 1980 drilling operation at the Point Thompson #4 well: Final report of L. G. L. Ecological Research Associates, Inc., prepared for Exxon Company, U.S.A., under contract No. WD-100, 62 p.

Yeend, Warren, 1973, Preliminary geologic map of a prospective transportation route from Prudhoe Bay, Alaska, to the Canadian border, Mount Michelson quadrangle: U.S. Geological Survey Miscellaneous Field Studies Map MF-494, scale 1:125,000.

APPENDIX A

PROPOSED DRAFT REGULATIONS

[4310-55]

DEPARTMENT OF THE INTERIOR

Fish and Wildlife Service

50 CFR Part 37

Geological and Geophysical Exploration of the Coastal Plain, Arctic National Wildlife Refuge, Alaska

AGENCY: Fish and Wildlife Service, Interior

ACTION: Proposed rule.

SUMMARY: This proposed rulemaking would establish guidelines governing the carrying out of exploratory activities on the coastal plain of the Arctic National Wildlife Refuge (ANWR). The promulgation of such guidelines by regulation is required by section 1002 of the Alaska National Interest Lands Conservation Act (ANILCA). The proposed regulations would prescribe how to obtain approval to conduct exploratory activities and limitations on the ways in which they may be conducted. The purpose of such exploration is to obtain data and information about the oil and gas production potential of the coastal plain, which will be used in preparing a report to Congress. The report will contain, among other things, a recommendation on the desirability of further oil

and gas exploration, development, and production in the area and an evaluation of their adverse effects on ANWR's fish and wildlife, their habitats, and other resources.

DATE: Comments on this proposed rulemaking must be received by (insert date 45 days from the date of publication in FEDERAL REGISTER).

ADDRESS: Comments may be mailed to: Robert A. Jantzen, Director, U.S. Fish and Wildlife Service, Attention: Associate Director for Wildlife Resources, Department of the Interior, Washington, D.C. 20240.

FOR FURTHER INFORMATION CONTACT: Mr. James Gillett, Chief, Division of Refuge Management, U.S. Fish and Wildlife Service, Department of the Interior, Washington, D.C. 20240, (202) 343-4791.

SUPPLEMENTARY INFORMATION: By memorandum, dated March 12, 1981, the Secretary of the Interior transferred responsibility for drafting the exploration guidelines required by section 1002 of ANILCA from the U.S. Fish and Wildlife Service (FWS) to the U.S. Geological Survey (GS). The Public Notice of Intent to draft regulations and prepare an Environmental Impact Statement (EIS) for oil and gas exploration on ANWR was published in the Federal Register on July 14, 1981 by the GS. Public meetings to identify issues and scope the EIS were conducted by GS in Anchorage, Fairbanks, Kaktovik, Arctic Village, and Barrow, Alaska; and Washington, D.C.; in August

and September of 1981. The FWS will be the administering agency for this exploratory program, as a direct result of the ruling of the U.S. District Court for the District of Alaska on November 2, 1981 in a suit brought by the Trustees for Alaska and other plaintiffs, requiring that full responsibility for preparation of the regulations and EIS be assigned to FWS. "Trustees for Alaska v. Watt," Civ. No. A81-264 (D. Ak., Nov. 2, 1981). In the court's declaratory judgment of December 4, 1981, the FWS was also directed to prepare documentation containing determinations by the Service as to which portions of the work, actions, and products to that date were approved or disapproved. The FWS reviewed the scoping process, as conducted by GS, and found that the hearings allowed for adequate participation by interested parties and adopted the results of the scoping process. These public meetings identified a number of issues related to oil and gas exploration on the ANWR. All comments have been considered in the formulation of the proposed regulations.

Environmental groups suggested that exploration activities should be monitored by FWS personnel having the authority to rectify or stop activities that would result in significant adverse impacts to the surface resources of the ANWR. As suggested above, the FWS will be the permitting authority for the exploratory activities, and it plans to designate field monitors to monitor field operations. Furthermore, the rule proposed in section 37.43 allows for suspending or modifying exploratory activities at any time after

determining that continuing further activities would significantly adversely affect the refuge's wildlife, habitat or the environment. A suspension would remain in effect until the basis for the suspension has been corrected. Under the proposed section 37.42, the field monitors would have the power to exercise the full authority of the FWS' Regional Director, who is the official proposed to administer the ANWR exploration program, except that they could normally not modify an approved exploration plan or plan of operation without his concurrence. Therefore, this limitation on their authority, which is found in the proposed section 37.42, would apply to certain of their actions under the proposed section 37.43 dealing with suspension and modification. This limitation would not, however, prevent the field monitors from suspending activities and/or modifying a permittee's special use permit pursuant to section 37.43 to the extent that their actions on the permit would not effect a modification in the associated plans.

Environmental and Native groups and industry representatives were in general agreement that all feasible alternative methods of oil and gas exploration should be considered, with selection of the one(s) that will provide the essential data with no significant adverse effect. This proposed rule allows the applicant to propose any geological and geophysical method or technique as long as the method or technique meets the environmental limitations and safeguards delineated in Subpart D and is otherwise consistent with the proposed regulations. This rule provides a moderate level of

regulatory guidance on the actual methods employed and allows the applicant to consider the full array of available technologies in designing its exploratory activities to meet the Service's requirements. Furthermore, because the ANWR was established to conserve the wildlife resources found therein, the FWS encourages applicants to use their creativity in designing plans that will maximize resource protection, consistent with the data gathering objective proposed in section 37.1.

Industry representatives suggested that the confidentiality of collected data should be protected for 10 years following leasing and environmental groups suggested seismic information should be made public immediately. The proposed section 37.54 proposes, as mandated by ANILCA, that the Department shall make raw data and information obtained as a result of carrying out exploratory activities available to the public. To do so, the FWS proposes to use the procedural requirements of the Freedom of Information Act, 5 U.S.C. Section 552, and 43 CFR Part 2. The Department shall withhold from the public all processed, analyzed, and interpreted information or data until 2 years after any lease sale including the area within the refuge from which they were obtained. Thereafter, such data or information would be treated like raw data and information. Oil and gas leasing within ANWR is presently prohibited by section 1003 of ANILCA.

Both the environmental groups and the Native representatives expressed their concern for protection of archeological, cultural

and historical sites. The proposed section 37.31 contains specific provisions to protect these resources. Each permittee would be required to obtain cultural resource reconnaissance reports, maps and other documents which identify all known cultural resource sites. Vehicles or seismic trains would not be allowed to pass through or over known cultural resources sites with standing structures, or to camp or to discharge petroleum or petroleum products on known cultural resource sites. The proposed subsection 37.31(d) would also require a permittee to conduct certain historic and archeological resource surveys and data recovery and to take other measures designed to protect such resources, if ordered by the FWS to do so.

Native representatives expressed concern over preserving subsistence species for continuing subsistence uses on the coastal plain of the ANWR. These regulations were developed in consideration of the probable impacts of aerial and surface geological and geophysical exploration methods. By designing the proposed guidelines so as to assure that authorized exploratory activities do not significantly adversely affect the ANWR's fish and wildlife, their habitats, or environment, the authors believe that they would have the additional result of protecting subsistence uses and needs. However, the proposed subsection 37.22(e) requires the Regional Director, who is the official proposed to have the power to approve or disapprove exploration plans, to evaluate the effect of proposed exploratory

activities on subsistence uses and needs in the course of evaluating an exploration plan. If he were to determine that a plan would significantly restrict subsistence uses, the subsistence issue would be joined in any public hearing held on the exploration plan.

The general standards which would govern the conduct of exploratory activities are stated in the proposed section 37.11. They are amplified by the proposed provisions of Subpart D. Any applicant wishing to submit an exploration plan should ensure that the information provided to the FWS pursuant to the proposed subsections 37.21(c) and (d) reflects how its proposed plan would satisfy these performance standards, as well as the objective and limitations stated in the proposed section 37.1 and any other proposed requirements.

The proposed subsection 37.22(a) would authorize the Regional Director to approve or disapprove an exploration plan in whole or part and to require applicants to conduct exploratory activities in assigned areas or jointly with other applicants. Joint exploration is distinct from group participation, which is covered in the proposed section 37.13. The proposed regulations would give the Regional Director the option of employing either or both in certain circumstances. The proposed subsection 37.22(a) would also authorize the Regional Director to disapprove an exploration plan if the applicant does not demonstrate to his reasonable satisfaction

its adequate technical and financial ability to conduct integrated and well designed exploratory activities in an arctic or subarctic environment and a history of responsible compliance with any prior exploration permits.

Under the proposed guidelines applicants would be given two opportunities to submit exploration plans. The proposed subsection 37.21(b) specifies the particular dates on which the plans would have to be submitted and the periods that they could cover. Applications would not be received at any other times. The authors of these proposed regulations consider these limitations necessary and fair since the exploration program is a short-term assessment and the FWS needs to compare any exploration plans submitted in order to determine their potential for unnecessary duplication, but must make the determination of consistency required by subsection 1002(e)(2) of ANILCA within 120 days of each plan's submission. Any applicant would be able to apply on either occasion or both. If, however, an applicant that submits an exploration plan on the first date contemplates submitting another plan on the second date, it would have to describe in its first plan how its activities covered by that plan would be integrated with any activities to be covered in the future plan. All plans submitted on the second date must include a proposal for conducting an integrated program of explorations activities necessary to satisfy the proposed section 37.1. In other words, such plans would have to show how the applicant intended to conduct a coordinated and complete exploration program in order to produce the results described in section 37.1,

by addressing such topics as the relationship between the various exploratory methods and techniques proposed, their sequence and location, and data quality and compatibility. The proposed regulations would not require exploration plans to be comprehensive, so that an applicant could apply for approval to explore the entire coastal plain or portions of it, as the applicant chooses. The proposed regulations, however, would allow the Regional Director to assign areas for exploration. This authority would permit the FWS to ensure that the entire coastal plain, excepting areas of special sensitivity, is explored, if it wishes to do so. The proposed regulations also do not limit the number of exploration plans that an applicant can submit. This feature would allow applicants to propose alternate exploration strategies. All exploration plans submitted would be published for public review and comment. The costs of the review process would be borne by the applicant under the proposed section 37.46.

An exploration plan is the way in which a program of exploratory activities is proposed to be arranged and carried out. A plan of operation is the detailed procedures, covering a period not to exceed 12 months, proposed for executing an exploration plan. The contents of a plan of operation are described in the proposed subsection 37.21(e). A plan of operation would not be part of the applicant's exploration plan. It would be a separate document showing how the exploration plan would be implemented. No plan of

operation could be approved unless the Regional Director determines that it is consistent with the exploration plan to which it pertains and with the proposed regulations.

Subsection 1002(b)(2) of ANILCA defines "exploratory activity" to mean "surface geological exploration or seismic exploration, or both, for oil and gas within the coastal plain." The proposed guidelines would expand the allowable types of geophysical exploration techniques in order to allow for the collection of aeromagnetic and/or aerogravimetric data and information. Whether magnetic or gravimetric surveys are conducted by helicopter or fixed winged aircraft, surface impacts associated with these exploratory techniques would be very limited and would allow for reconnaissance-level data collection to assist in delineating the extent and major structural features of sedimentary basins. The overview provided by these surveys would provide a basis for a systematic and efficient exploration program for the coastal plain, which the authors believe is consistent with the intent of ANILCA.

The purpose of the definition of "exploratory activities" found in the proposed subsection 37.2(i) is to enable an applicant to satisfy the statutory requirement that an exploration plan must be consistent with the FWS' guidelines in order to be approved should its plan contemplate aerial exploration as a part of its overall exploration program. The proposed definition is not intended to suggest that the FWS is asserting under its proposed guidelines any

regulatory control over aircraft traversing the navigable airspace above ANWR's coastal plain, provided that such aircraft is not involved in any aircraft - supported exploration activities using or occupying the coastal plain's surface or in the harassment of wildlife.

Drilling of exploratory wells would be prohibited by the proposed subsection 37.11(d).

Subsection 1002(d)(1) of ANILCA requires that the guidelines established by the Department include certain provisions. The first and second provisions would require a prohibition on exploratory activities during caribou calving or post-calving seasons and a temporary or permanent closing of appropriate areas to activities where human activities may disturb the valuable surface resources. The proposed section 37.32 would provide a mechanism for satisfying these requirements. The third requirement is to specify the types of equipment, facilities, and manpower that is appropriate to carry out exploratory activities. The proposed subsection 37.12(b), 37.31(b)(2) and 37.31(e)(4), (5), and (8) address this requirement. The fourth specific requirement is to coordinate exploratory activities so as to avoid unnecessary duplication. The proposed regulations contain a number of mechanisms, discussed above, which are designed to meet this requirement.

In addition to complying with the regulations that are finally adopted, the FWS expects that applicants, permittees, and other persons whose activities would be governed by them will comply with all other applicable laws. Accordingly, the proposed subsection 37.3 states that nothing in the proposed Part 37 shall be construed to relieve them from complying with any applicable federal laws or any applicable state laws, the requirements of which are not inconsistent with the Part. For example, subsection 307(c)(3)(A) of the Coastal Zone Management Act of 1972, as amended, requires any applicant for a required federal permit to conduct an activity affecting land or water uses in the coastal zone of a state having an approved coastal zone management program to provide in its application to the permitting agency a certification that its proposed activity complies with the state's management program and that such activity will be conducted in a manner consistent with that program. At the same time the applicant is also required by subsection 307(c)(3)(A) to furnish the state with a copy of its certification, along with all necessary information and data. Therefore, any applicant submitting an exploration plan covering exploratory activities which would affect land or water uses in Alaska's coastal zone is encouraged to seek the assistance of the State of Alaska's Division of Policy Development and Planning early in its planning effort, so that in the submission of its exploration plan to the FWS it can satisfy subsection 307(c)(3)(A) to the extent that it applies to the applicant's proposed activities.

In accordance with subsection 1002(d)(2) of ANILCA the proposed guidelines are accompanied by an environmental impact statement (EIS) on exploratory activities. A separate notice informing the public of the availability of the draft EIS accompanying the guidelines is being published in the FEDERAL REGISTER. The EIS is available from the FWS at the same address given for submission of comments on the proposed rule. The FWS recommends the EIS be consulted for further discussion, explanation, and analysis of the anticipated environmental impacts of the proposed rule.

The Department has determined that this document is not a major rule under Executive Order 12991 and certifies that this document will not have a significant economic effect on a substantial number of small entities under the Regulatory Flexibility Act (5 U.S.C. § 601 et seq.). Furthermore, since the FWS anticipate that there will be fewer than ten applicants on respondents annually information collections are not subject to Office of Management and Budget clearances under the Paperwork Reduction Act of 1980 (44 U.S.C. § 3507).

List of subjects in 50 CFR, Part 37: Alaska, Oil and gas exploration, Wildlife refuges.

Under the authority of section 1002 of the Alaska National Interest Lands Conservation Act, 94 Stat. 2449 (16 U.S.C. § 3142), section 501 of Pub. L. 137, 65 Stat. 290 (31 U.S.C. § 483a), 5 U.S.C. § 301, and 209 DM 6.1, it is proposed to establish new rules for Subchapter C of Chapter I, Title 50 of the Code of Federal Regulations as set forth below.

Dated: 8/20/82

Acting Assistant Secretary for Fish and Wildlife and Parks

50 CFR

Part 37 - Geological and Geophysical Exploration of the Coastal Plain, Arctic National Wildlife Refuge, Alaska

Subpart A - General Provisions

Section

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Subpart E - General Administration

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Subpart F - Reporting and Data Management

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37.54 Disclosure.

AUTHORITY: Sec. 1002, Pub. L. 96-487, 94 Stat. 2449 (16 U.S.C. 3142); Sec. 501, Pub. L. 137, 65 Stat. 290 (31 U.S.C. 483a); 5 U.S.C. 301; 209 DM 6.1.

Subpart A - General Provisions

§ 37.1 Purpose.

These regulations implement the requirement of § 1002(d) of the Alaska National Interest Lands Conservation Act, 94 Stat. 2450, 16 U.S.C. § 3142(d), that the Secretary establish guidelines governing surface geological and geophysical exploration for oil and gas within the coastal plain of the Arctic National Wildlife Refuge. Section 1002 mandates an oil and gas exploration program for the refuge's coastal plain. The program shall culminate in a report to Congress which contains, among other things, the identification of those areas within the coastal plain that have oil and gas production potential, an estimate of the volume of oil and gas concerned, the description of the wildlife, its habitat, and other resources that are within the areas identified, and an evaluation of the adverse effects that the carrying out of further exploration for, and the development and production of, oil and gas within such areas will have on the refuge's resources. It is the objective of this program to ascertain the best possible data and information concerning the probable existence, location, volume, and potential for further exploration, development, and production of oil and gas within the coastal plain. This objective is subject to the limitations that exploratory activities not significantly adversely affect the wildlife, its habitat, or the environment and that unnecessary duplication of exploratory activities be avoided. These

regulations prescribe the requirements and procedures for obtaining authorization for and the conduct of such exploratory activities, and for submitting to the Department the resulting data and information. These regulations also describe other matters relating to the administration of the program.

§ 37.2 Definitions.

The following definitions are applicable to the sections of this part.

(a) "Act" means § 1002 of the Alaska National Interest Lands Conservation Act, 94 Stat. 2449, 16 U.S.C. § 3142.

(b) "Adequate protective cover" means snow or a frostline, or both, sufficient to protect the vegetation and soil from significant adverse effects due to the operation of surface equipment, as determined by the Regional Director.

(c) "Coastal lagoons" means the waters and submerged lands between the mainland and the offshore barrier islands that lie between Brownlow Point and the Aichilik River within the coastal plain.

(d) "Coastal plain" means that area shown on the map entitled "Arctic National Wildlife Refuge", dated August 1980, and legally described in Appendix I hereto.

(e) "Cultural resource" means any district, site, building, structure, or object significant in American history, architecture,

archeology, engineering or culture, as determined in accordance with 36 CFR § 60.6.

(f) "Department" means the Department of the Interior and any of its component bureaus and offices.

(g) "Director" means the Director of the U.S. Fish and Wildlife Service or his authorized representative.

(h) "Exploration plan" means the way in which a program of exploratory activities is proposed to be arranged and carried out.

(i) "Exploratory activities" means aerial and surface geological exploration or geophysical exploration or both within the refuge's coastal plain, and all related activities and logistics required for either or both.

(j) "Harass" means an intentional or negligent act or omission which actually kills or injures wildlife or which creates the likelihood of death or injury to wildlife, by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding or sheltering.

(k) "Hazardous substances" means petroleum, petroleum products, toxic materials, shot wire, chemical effluent, explosives, or other materials which are likely to cause adverse effects to the refuges wildlife, its habitat, the environment, or humans.

(l) "Permittee" means the person authorized by a special use permit issued pursuant to this part to conduct exploratory activities on the coastal plain; any official, employee, contractor, subcontractor or agent of the permittee or of the permittee's designee; and any participant to the permittee's permit.

(m) "Person" means any individual, partnership, firm, corporation, association, organization, or agency.

(n) "Plan of operation" means detailed procedures, covering a period not to exceed 12 months, proposed for executing an exploration plan.

(o) "Processed, analyzed and interpreted data or information" means any data or information which results from any subsequent modification, processing, analysis, or interpretation of raw data and information by human or electronic means, on or off the refuge.

(p) "Raw data and information" means all original observations and recordings in written or electronic form and samples obtained during field operations.

(q) "Refuge" means the Arctic National Wildlife Refuge.

(r) "Regional Director" means the Regional Director, Region 7 of the U.S. Fish and Wildlife Service, or his authorized representative.

(s) "Rehabilitation" means the act of returning the landform and vegetation to as near its original shape and condition as practicable, as determined by the Regional Director.

(t) "Secretary" means the Secretary of the Interior or his authorized representative.

(u) "Service" means the U.S. Fish and Wildlife Service.

(v) "Solicitor" means the Solicitor of the Department of the Interior or his authorized representative.

(w) "Special use permit" means a revocable, nonpossessory privilege issued in writing by the Regional Director and authorizing

the permittee to enter and use the refuge for a specified period not greater than 12 months to conduct exploratory activities, and other activities necessary thereto.

(x) "Support facilities" means facilities on or near the refuge used to provide logistical support for the field exploratory activities.

(y) "Third party" means any person other than a representative of the permittee or the United States government.

(z) "Waste" means all material for discard from exploratory activities. It includes, but is not limited to, human waste, trash, garbage, refuse, fuel drums, ashes, and functional and nonfunctional equipment.

(aa) "Wildlife" means fish or wildlife or both.

(bb) "Year" means, unless otherwise indicated by the context, the fiscal year, which shall begin on October 1 of any calendar year and end on September 30 of the following calendar year.

§ 37.3 Other applicable laws.

(a) Nothing in this part shall be construed to relieve an applicant, permittee or any person from complying with any applicable federal laws or any applicable state laws, the requirements of which are not inconsistent with this part.

(b) Until the litigation between the United States and the State of Alaska over title to the submerged lands of the coastal lagoons, "United States v. Alaska", Sup. Ct., No. 84, Orig. (1979),

is resolved, the permittee shall satisfy both federal and state requirements for conducting oil and gas exploration in the coastal lagoons. In the event of an inconsistency between such requirements the permittee shall satisfy that requirement which provides the greatest environmental protection.

(c) Before conducting exploratory activities on lands in the coastal plain which have been conveyed to or selected by the Kaktovik Inupiat Corporation, a permittee must furnish to the Regional Director a letter of concurrence from the Corporation.

§ 37.4 Disclaimer.

Authorization granted under this part to conduct exploratory activities shall not confer a right to any discovered oil, gas, or other mineral in any manner.

Subpart B - General Requirements

§ 37.11 General standards for exploratory activities.

(a) No exploratory activities shall be conducted without a special use permit. Requirements and procedures for obtaining a special use permit are prescribed in §§ 37.21 through 37.24.

(b) Exploratory activities shall be conducted so that they do not:

(1) Significantly adversely affect the refuge's wildlife, its habitat, or the environment;

(2) Unnecessarily duplicate exploratory activities of the permittee or another permittee; and

(3) Unreasonably or significantly interfere with another permittee's activities.

(c) Reexamination of an area may be permitted by the Regional Director if necessary to correct data deficiencies or to refine or improve data or information already gathered.

(d) Drilling of exploratory wells is prohibited.

§ 37.12 Responsibilities of permittee.

(a) The permittee shall comply with the regulations of this section, the terms and conditions of its special use permit, the provisions of its approved exploration plan and plan of operation, and all reasonable stipulations, demands and orders issued by the Regional Director. All actions by the permittee inconsistent with this part are prohibited.

(b) The permittee shall designate a general representative who shall be the person primarily accountable for managing the permittee's authorized activities, and a field representative who shall be the person primarily accountable for supervising the

permittee's field operations, and their alternates. The permittee shall notify the Regional Director promptly of any changes in such personnel or the procedures for contacting them.

(c) Field operations shall be conducted by the permittee or a designee approved by the Regional Director. Assignment of a designee shall be in a manner and form acceptable to the Regional Director. Acceptance of a designee to act for the permittee in matters relating to the conduct of exploratory activities does not relieve the permittee of responsibility for compliance with applicable laws, its special use permit, exploration plan, plan of operation, and all reasonable stipulations, demands and orders of the Regional Director. The designee will be considered the agent of the permittee and will be responsibile for complying fully with the obligations of the permittee. The serving of stipulations, demands, orders, and notices on the permittee's designee, when delivered personally or by radio or mail, will be deemed to be service upon the permittee. The permittee shall notify the Regional Director in writing when assignment of a designee has been cancelled. A designee cannot reassign its designation to another party. The permittee or designee shall notify the Regional Director 5 working days in advance of its intention to commence field operations for each season that it conducts exploratory activities.

(d) The permittee shall submit to the Regional Director 30 days prior to the commencement of field operations for each year covered

by its exploration plan an updated list of the names and addresses referred to in § 37.21(d)(3).

(e) The permittee shall perform operations and maintain equipment in a safe and workmanlike manner. The permittee shall take all precautions necessary to provide adequate protection for the health and safety of life and the protection of property and to comply with any health and safety requirements prescribed by the Regional Director.

§ 37.13 Group participation.

(a) To avoid unnecessary duplication of exploratory activities, the permittee shall, if ordered by the Regional Director, afford all interested persons, through a signed agreement, an opportunity to participate in its exploratory activities and share the resulting data and information on a cost-sharing basis. The provisions of the agreement for sharing the cost of exploratory activities may include a penalty for late participants of not more than 100 percent of the cost to each original participant in addition to the original share cost. The original share cost shall be computed by dividing the estimated total cost of implementing the permittee's approved exploration plan by the number of original participants. The permittee shall assess and distribute penalties in accordance with the terms of the agreement.

(b) To allow for group participation in its exploratory activities, the permittee shall:

(1) Within 30 days of receiving the Regional Director's order, submit to the Regional Director for approval, a summary statement to be published by the permittee in newspapers of general circulation in the State of Alaska which describes the permittee's exploration plan;

(2) Within 30 days after receiving approval of its summary statement, cause to be published such statement in a manner approved of or prescribed by the Regional Director;

(3) Provide copies of the published statement to the Regional Director;

(4) Allow at least 30 days from the date of publishing the summary statement for other persons to join as late participants; and

(5) Furnish the Regional Director with the names and addresses of all original participants and all late participants, as they join.

(c) If, with the approval of the Regional Director, the permittee at any time changes any provisions of its approved exploration plan relating to areal extent, intensity of exploratory activities, or logistical support, and the Regional Director determines such changes to be significant, the Regional Director may require the permittee to afford all interested persons another opportunity to participate in the permitted exploratory activities in accordance with subsections (a) and (b) of this section.

(d) The requirements of this section do not preclude the permittee from initiating field operations as authorized under its special use permit.

(e) All participants shall be bound by the regulations of this part, the permittee's special use permit, approved exploration plan and plan of operation and any reasonable stipulations, demands and orders issued by the Regional Director.

§ 37.14 Bonding.

(a) Within 30 days of the issuance of its special use permit, the permittee shall furnish to the Service a corporate surety bond of not less than $100,000, or other security satisfactory to the Service, to secure performance of its exploration plan and plan of operation and compliance with the permit and this part. Any bond furnished or maintained by a person under this section shall be on a form approved or prescribed by the Regional Director.

(b) Whenever a permittee's exploration plan, plan of operation, or special use permit is revised or modified, the permittee shall provide to the Regional Director within 30 days thereafter an acknowledgement by the surety that its bond continues to apply to the exploration plan, plan of operation or special use permit, as revised or modified, unless a waiver of notice to the surety is contained in the bond or the surety is not otherwise released by the

revision or modification, or unless the permittee provides to the Service an increased or additional bond.

(c) Recovery of the amount specified in the permittee's bond or other security shall not preclude the Department from seeking specific performance by the permittee of any obligations not satisfied by enforcement of the bond or security, or compensation for any damages, losses or costs due to the permittee's activities which exceed the amount recovered, by pursuing the Department's legal remedies.

Subpart C - Exploration Plans

§ 37.21 Application requirements.

(a) Prior to submitting an exploration plan, applicants may meet with the Regional Director to discuss their proposed plans and exploratory activities and the requirements of this part.

(b) Any person wanting to conduct exploratory activities may apply for a special use permit by submitting for approval one or more written exploration plans, in triplicate, to the Regional Director, Region 7, U.S. Fish and Wildlife Service, 1101 East Tudor Road, Anchorage, Alaska 99503. To be considered, exploration plans covering the period from the inception of the program through September 30, 1983 or any portions thereof must be received by the Regional Director during normal business hours on (the 31st day

following the date of the final promulgation of these regulations) and exploration plans covering the period from October 1, 1983 through May 31, 1986 or any portions thereof must be received by the Regional Director during normal business hours on March 1, 1983. The Regional Director shall approve in accordance with § 37.22 any exploration plan which, in his judgment, is consistent with this part.

(c) In addition to containing the information required in subsection (d) of this section, any exploration plan submitted shall describe the applicant's plan for carrying out a program of exploratory activities in such a manner as will satisfy the objective and limitations stated in § 37.1. Although the term of any exploration plan submitted on (the 31st day following the date of the final promulgation of these regulations) may not extend beyond September 30, 1983, the applicant shall describe in that plan how its future exploratory activities, if any are contemplated, will be integrated with those proposed under its initial plan. Any exploratory plan submitted on March 1, 1983 must entail an integrated program of exploratory activities necessary to satisfy section 37.1. Each exploration plan submitted must be published and be the subject of a public hearing in accordance with requirements of § 37.22(b).

(d) An exploration plan shall set forth in general terms such information as is required by this part and by the Regional Director

in determining whether the plan is consistent with this part, including, but not limited to:

(1) The name and address of any person who will conduct the proposed exploratory activities, i.e., the applicant/permittee, and, if that person is an agency, partnership, firm, corporation, organization, or association, the names and addresses of the responsible officials and all partners or, in the case of a corporation, all shareholders of more than 5% interest therein, together with the number and percentage of any class of voting shares which each such shareholder is authorized to vote;

(2) The names, addresses, and telephone numbers of the persons to be designated in accordance with § 37.12(b), and a description of the procedures for contacting them on a 24-hour basis, which shall include the radio frequency for field operations;

(3) The names and addresses of all persons planning at the time of plan submittal to participate in the proposed exploratory activities or share in the data and information resulting therefrom through a cost-sharing or any other arrangement;

(4) Evidence of the applicant's technical and financial ability to conduct integrated and well designed exploratory activities in an arctic or subarctic environment and of the applicant's responsibility in complying with any exploration permits previously held by it;

(5) A statement of the geographic areas in which exploratory activities are proposed and the applicant's proposed method of access and travel routes;

(6) A general description of the type of exploratory activities planned, including alternate exploratory methods and techniques proposed should those planned not work, and the manner and sequence in which such activities will be conducted;

(7) A description of how various exploratory methods and techniques will be utilized in an integrated fashion to avoid unnecessary duplication of the applicant's own work and any other applicant's activities;

(8) A description of the applicant's proposed communication techniques;

(9) A description of the equipment, support facilities and personnel that will be used in carrying out exploratory activities;

(10) A hazardous substances control and contingency plan describing actions to be taken to control, clean up, and dispose of these materials in the event of a spill or accident;

(11) A general description of the anticipated impacts that the proposed exploratory activities may have on the refuge's wildlife, its habitat, the environment, subsistence uses and needs and cultural resources; and a description of mitigating measures which will be implemented to minimize or avoid such impacts;

(12) A description of the proposed procedures for monitoring the environmental impacts of its operation and its compliance with all regulatory and permit requirements;

(13) A description of provisions for facilitating group participation in the exploration program in order to avoid unnecessary duplication of exploratory activities;

(14) A statement that, if authorized to conduct exploratory activities, the applicant shall comply with this part, its special use permit, its approved exploration plan, plan of operation, and all reasonable stipulations, demands and orders issued by the Regional Director;

(15) A statement on the type and quality of data and information to be obtained through the planned and alternate exploratory activities; and

(16) Such other pertinent information as the Regional Director may reasonably require.

(e) Each exploration plan shall be accompanied by a written plan of operation specifying the field operations proposed to be implemented during each year or portions thereof covered by the exploration plan, except that any plan of operation covering exploratory activities occurring after September 30, 1984 shall not be submitted to the Regional Director until 90 days before field operations are proposed to be commenced for that year or field season. A plan of operation shall set forth such site-specific information as is required by this part and by the Regional Director in determining whether the plan is consistent with the exploration plan to which it pertains and with this part, including, but not limited to:

(1) A statement as to whether the field operations are to be conducted by the permittee or its designee, and, if the latter, the name and address of the designee;

(2) A detailed description of the type of exploratory activities planned, including alternate exploratory methods and techniques proposed should those planned not work, and the manner and sequence in which such activities will be conducted;

(3) A detailed schedule for the exploratory activities proposed, including the dates on which the various types of exploratory activities are proposed to be commenced and completed;

(4) A detailed description of the major equipment, support facilities, methods of access and travel routes to and within the refuge, and personnel that will be used, together with a map (1:250,000) of the proposed locations of travel routes, fuel caches, and major support facilities;

(5) A detailed description of any proposed storage and uses of explosives;

(6) The locations in the refuge where exploratory activities will be undertaken, including a separate map (1:250,000) of proposed exploratory areas and survey lines; and

(7) Such other pertinent information as the Regional Director may reasonably require.

§ 37.22 Approval of exploration plan.

(a) No exploration plan shall be approved by the Regional Director unless he determines that it satisfies the requirements of §§ 37.21(c) and 37.21(d) and is otherwise consistent with the Act and the regulations of this part. In order to meet the objective and limitations stated in § 37.1, enforce the standards stated in § 37.11(b), or minimize adverse impacts on subsistence uses, the Regional Director may approve or disapprove any exploration plan in whole or in part or may require, as a condition of approval, an applicant to conduct its exploratory activities in an assigned area or jointly with other applicants or to make such modification in its exploration plan as he considers necessary and appropriate to make it consistent with this part. No plan shall be approved before December 3, 1982. Furthermore, no plan shall be approved if the applicant submitting it does not demonstrate to the reasonable satisfaction of the Regional Director its adequate technical and financial ability to conduct integrated and well designed exploratory activities in an arctic or subarctic environment, and a history of responsible compliance with any exploration permits that it or its responsible officials, partners, or shareholders of more than 5% interest, may have previously held.

(b) Upon receipt of an exploration plan submitted in accordance with § 37.21(b), the Regional Director shall promptly publish notice of the application and text of the plan in the Federal Register and newspapers of general circulation in the State of Alaska. The Regional Director shall determine within 120 days after the plan is

submitted whether the plan is consistent with this part. Before making his determination, the Regional Director shall hold at least one public hearing in the State for the purpose of receiving public comments on the plan. The Regional Director shall give the applicant written notice of his determination.

(c) Whenever the Regional Director disapproves an exploration plan in whole or in part, he shall notify the applicant in writing of the reasons for his disapproval. The applicant may request the Director to consider that which was disapproved by the Regional Director by filing a written request with the Director, U.S. Fish and Wildlife Service, Department of the Interior, Washington, D.C. 20240, within 30 days from the date of disapproval. Such a request shall not operate to stay the Regional Director's disapproval. The request shall:

(1) State fully the basis for the applicant's disagreement with the Regional Director's determination;

(2) Include any statement or documentation, in addition to that already submitted by the applicant with its application, which demonstrates that the applicant's exploration plan is consistent with this part; and

(3) Indicate whether or not the applicant requests an informal hearing before the Director.

The Director shall provide an informal hearing if requested by the applicant. Within 30 days of the receipt of the applicant's request for reconsideration or of the applicant's hearing, if any, whichever

is later, the Director shall affirm, reverse, or modify the Regional Director's determination. Written notice of the Director's decision and the reasons therefor shall be provided promptly to the applicant. The Director's decision shall constitute the final administrative decision of the Secretary in the matter.

(d) The Regional Director, as a condition of approval of any exploration plan under this section, shall:

(1) require that all data and information (including processed, analyzed and interpreted information) obtained as a result of carrying out the plan shall be submitted to the Regional Director, as provided in § 37.53; and

(2) make such data and information available to the public, except that any processed, analyzed and interpreted data or information shall be held confidential by the Department for a period of not less than 2 calendar years following any lease sale including the area within the refuge from which the information was obtained, as provided in § 37.54.

(e) In the course of evaluating an exploration plan, the Regional Director shall also evaluate the effect of the proposed exploratory activities on subsistence uses and needs, the availability for exploration of alternate areas within the coastal plain, and alternatives to the proposed activities which would reduce or eliminate the use of areas within the coastal plain needed for subsistence purposes. If the Regional Director finds that the

exploration plan, if approved, would significantly restrict subsistence uses, he shall satisfy the requirement to hold a hearing on this issue by incorporating it in any hearing held pursuant to subsection (b) of this section and shall otherwise satisfy the procedural requirements of § 810(a) of the Alaska National Interest Lands Conservation Act, 94 Stat. 2427, 16 U.S.C. § 3120, before approving the plan.

§ 37.23 Special use permit.

Within 60 days, or sooner if practicable, of approving an exploration plan, the Regional Director shall, unless prohibited by law, issue a special use permit to authorize the permittee to proceed with those exploratory activities described in its exploration plan and delineated in the plan of operation accompanying the exploration plan. No exploratory activities will be authorized by any permit unless they are described and approved in both the permittee's exploration plan and plan of operation. The special use permit may contain such terms and conditions as the Regional Director deems necessary and appropriate to carry out the Act and this part. The Regional Director shall authorize exploratory activities solely on an annual basis, but may annually reauthorize activities described in an approved exploration plan covering more than one year as they are further described and approved in any supplemental plans of operation. Such

reauthorization shall be granted by the issuance of a new special use permit within 60 days of the receipt of a supplemental plan of operation approved by the Regional Director.

§ 37.24 Approval of plan of operation.

No plan of operation shall be approved by the Regional Director unless he determines that it is consistent with the approved exploration plan to which it pertains and with this part. To ensure such consistency, the Regional Director may require such modifications in the plan of operation as he deems necessary and appropriate. Reconsideration of a plan of operation which has been disapproved in whole or in part may be obtained by employing the procedures described in § 37.22(c). A request for reconsideration shall not operate to stay the Regional Director's disapproval.

§ 37.25 Revision.

A permittee may request the Regional Director for permission to revise its approved exploration plan or plan of operation. Such request shall be automatically granted on the 8th day following its receipt unless the Regional Director denies the request; advises the permittee that the proposed revision, if of the exploration plan, is major and, therefore, must satisfy the publication and hearing requirements of § 37.22(b) before it can be acted upon; by timely written notice extends the period for considering the request; conditionally approves the proposed revision with such modifications

as he stipulates as necessary and appropriate; or, unconditionally approves the proposed revision within a shorter period. No revision of an exploration plan or plan of operation shall be approved that is inconsistent with the Act, this part, or, if of a plan of operation, the exploration plan to which the plan of operation pertains. Approval of any revision is subject to the conditions stated in §§ 37.22(b) and 37.22(c) to the extent that they are pertinent. Reconsideration of the Regional Director's actions under this section may be obtained by employing the procedures described in § 37.22(c). A request for reconsideration shall not operate to stay the Regional Director's actions unless such stay is granted in writing by the Director.

Subpart D - Environmental Protection

§ 37.31 Environmental protection.

(a) The permittee shall conduct operations in a manner which avoids significant adverse effects on the refuge's wildlife, its habitat, and environment. The Regional Director may impose stipulations to supplement the permittee's special use permit and issue other orders as needed to ensure that the permittee's activities are conducted in a manner consistent with this part. If, after 30 days, or in emergencies such shorter periods as shall not be unreasonable, following a demand by the Regional Director, the permittee shall fail or refuse to perform any action required by

this part, its exploration plan, plan of operation, special use permit, or a stipulation or order of the Refuge Manager, the Department shall have the right, but not the obligation, to perform any or all such actions at the sole expense of the permittee. Prior to making such demand, the Regional Director shall confer with the permittee, if practicable to do so, regarding the required action or actions included in the demand. Reconsideration of the Regional Director's demands under this section may be obtained by employing the procedures described in § 37.22(c). A request for reconsideration shall not operate to stay the Regional Director's demands or the Department's performance pursuant to this section unless such stay is granted in writing by the Director.

(b) Terrestrial environment. (1) Vehicles shall be operated in a manner such that the vegetative mat or soil is not significantly damaged or displaced. Blading of snow on trails or campsites shall be limited to the minimum amount necessary.

(2) Ground vehicles shall be of the type causing the least practicable harm to the surface, such as Nodwell FN-110 or FN-60 or Bombardier track vehicles, mobile camps on flexible tracks or skids, vibrator units on flexible tracks or wheels, D-7 tractors, or their equivalent. They shall be operated only in the winter and where there is adequate protective cover. Vehicle operation shall cease in the spring when the Regional Director determines that the protective cover is no longer adequate. Operation of ground vehicles in the summer is prohibited.

(3) Movement of equipment through riparian willow stands shall be avoided, except when approved by the Regional Director.

(4) Above ground explosive charges shall be utilized in a manner to minimize damage to the vegetative mat.

(5) Campsites may be located on durable ground or lakes or lagoons which are frozen throughout, including bottom sediments, but shall not be located on river ice. Durable ground can include gravel or sand bars or vegetated frozen ground with adequate protective cover.

(6) Campsites and trails shall be kept clean.

(7) Gray water may be discharged to the surface provided it is filtered, disinfected, and not discharged directly into lakes and rivers.

(8) The permittee shall take all precautionary measures necessary to prevent and suppress man-caused tundra fires and shall notify the Regional Director of the occurrence of any tundra fires immediately or as soon as communication can be established.

(9) Rehabilitation of disturbed surface areas shall be accomplished by the permittee in accordance with schedules and a plan required and approved by the Regional Director. Revegetation shall be accomplished exclusively with endemic species.

(10) The permittee shall not harass wildlife in any manner, including, but not limited to, close approach by surface vehicles or aircraft. Aircraft should maintain an altitude of 1500 feet above ground level whenever practicable.

(11) No explosives shall be detonated within 1/2 mile of any known denning brown or polar bear or any muskoxen herd.

(12) The permittee shall operate in such a manner as not to impede or restrict the free passage and movement of large mammals, including caribou, muskoxen, moose, polar bear, and brown bear.

(13) Feeding of wildlife is prohibited. This includes the leaving of garbage or edibles in a place which would attract wildlife. Garbage shall be kept in covered animal-proof containers while awaiting incineration.

(14) Hunting, fishing, and trapping by the permittee within the refuge are prohibited during the conduct of exploratory activities. Employing firearms in defense of life and property is allowed.

(c) Aquatic environment. (1) The permittee shall not significantly adversely affect the banks of streams, rivers, or lakes while conducting exploratory activities. Crossings of stream, river, or lake banks shall utilize a low angle approach or, if appropriate, snow bridges. Snow bridges shall be removed after use or prior to breakup each year.

(2) No water shall be removed from any stream, lake, river or subsurface source without the written permission of the Regional Director.

(3) No explosives shall be detonated closer than 1/8 mile from any river, stream, spring, or lake identified by the Regional Director to support fish populations in any life stage. However, during the winter, the permittee may utilize explosives on lakes or rivers which are frozen throughout, including bottom sediments.

(4) All operations shall be conducted in a manner that will not impede the passage of fish, disrupt spawning areas identified by the Regional Director or block or change the character or course of, or cause significant siltation or pollution of any stream, river, pond, pothole, lake, lagoon, or drainage system.

(5) No removal or compaction of snow shall occur on frozen river pools.

(6) Ground vehicles shall not cross active spring areas.

(7) No helicopters shall be operated in the summer within areas of waterbird nesting or staging, as designated by the Regional Director.

(d) Human environment. (1) Prior to implementing any plan of operation, the permittee shall obtain from the Regional Director copies of the cultural resource reconnaissance reports, maps and other available documents which identify all known cultural resource sites and areas of predicted high probability of containing cultural resources. The Regional Director may reasonably restrict exploratory activities in these areas to mitigate, minimize or avoid any adverse effects thereon.

(2) Unless otherwise specified by the Regional Director, the following prohibitions shall be in effect:

(A) No vehicle of any type shall pass over or through a known cultural resource site with standing structures;

(B) No seismic train shall camp on a known cultural resource site; and

(C) No discharge of petroleum or petroleum products shall be made on the surface of a known cultural resource site.

(3) If, after September 30, 1983, any exploratory activities require entry into areas known to contain historic or archeological resources, high probability areas, or areas previously unsurveyed for cultural resources, prior to the initiation of such activities, the permittee shall, if ordered by the Regional Director, locate, identify and evaluate properties eligible for listing on the National Register of Historic Places, recover for the Department archeological data contained in such properties, and take other measures designed to mitigate, minimize or avoid to the extent practicable any significant adverse effects on them. Such efforts shall be done in a manner prescribed or approved by the Regional Director and without expense or liability to the Department.

(e) General. (1) All spills or leakages of any hazardous substance, fires, fatalities, and any other conditions which threaten the refuge's resources, the environment, or human safety, shall be reported by the permittee to the Regional Director immediately or as soon as communication can be established. Other notifications shall be made by the permittee as required by applicable laws.

(2) All solid waste shall be incinerated and/or transported to a solid waste disposal site approved by the Regional Director. All other waste shall be removed or otherwise disposed of in a manner acceptable to the Regional Director and consistent with

applicable federal and state standards.

(3) All hazardous substances utilized and/or generated in conducting exploratory activities shall be contained, controlled, and cleaned up in accordance with the permittee's approved hazardous substances control and contingency plan. Such measures shall take precedence over all other matters except human safety.

(4) Unless exigencies warrant, in any field operations employing seismic exploration methods, the equipment, facilities, and personnel used shall not exceed that necessary to support a maximum of 6 simultaneously operating seismic crews per year.

(5) No fuel storage facilities shall be placed within the annual floodplain of fish bearing water courses or within 100 feet of any other water body, and no vehicle refueling shall occur within such areas except when approved by the Regional Director. All fuel storage sites shall be approved by the Regional Director. Fuel containers shall be properly stored and marked with the permittee's name, type of fuel, and last date of filling. All fuel containers, including those emptied, shall be capped when not in actual use.

(6) The permittee shall not disturb or damage any geodetic land survey monuments. If any monument is disturbed or damaged, the permittee shall reestablish it in a manner acceptable to the Regional Director.

(7) The timing and location of the detonation of explosives shall be approved in advance by the Regional Director.

(8) No permanent structures will be erected within the refuge. The type and location of temporary structures, including,

but not limited to, airstrips, for use in support of exploratory activities must be approved by the Regional Director.

§ 37.32 Special use areas.

The Regional Director may designate zones of restricted activity in important fish and wildlife areas within the refuge, in which exploratory activities will be restricted to protect wildlife, its habitat, or the environment from significant adverse effects during periods of biological sensitivity or other appropriate periods. The Regional Director will include such site-specific restrictions in the permittee's special use permit. In the event that the Regional Director determines that further site-specific restrictions are necessary during exploration operations, the Regional Director shall provide the permittee, as far in advance of such restriction as is possible, an updated list of those areas where such restrictions are required, together with the dates and types of restriction. Such restrictions are in addition to the following restrictions, which shall be observed in preparation of any exploration plan and plan of operation:

(a) Muskox Calving Special Area.

Area: See map on file at the refuge office in Fairbanks, Alaska.

Effective dates: April 15 through May 30.

Restrictions: Limited exploratory activities, as specified

by the Regional Director.

No helicopter overflight should be below 1500 feet in order to avoid harassment of wildlife.

(b) Polar Bear Denning Special Area.

Area: See map on file at the refuge office in Fairbanks, Alaska.

Effective dates: November 1 through April 15.

Restrictions: Limited exploratory activities, as specified by the Regional Director.

(c) Sadlerochit Spring Special Area.

Area: See map on file at the refuge office in Fairbanks, Alaska.

Effective dates: All year.

Restrictions: Limited exploratory activities, as specified by the Regional Director. No helicopter overflight should be below 1500 feet in order to avoid harassment of wildlife.

(d) Caribou Calving and Postcalving Special Area.

Area: See map on file at the refuge office in Fairbanks, Alaska.

Effective dates: May 10 through July 15.

Restrictions: No exploratory activities.

No helicopter overflight should be below 1500 feet in order to avoid harassment of wildlife.

§ 37.33 Environmental Briefing.

The permittee shall provide opportunities for the Regional Director to conduct environmental and other pertinent briefings for all of its personnel involved in field operations prior to commencement of field work. The permittee shall require the attendance of its personnel and arrange the time and place for such briefings upon the request of the Regional Director. In addition, the permittee shall provide a copy of this part to each employee involved with its exploratory activities.

Subpart E - General Administration

§ 37.41 Responsibilities of the Regional Director.

The Regional Director is authorized to approve exploration plans; issue special use permits; inspect and regulate exploratory activities; require compliance with the permittee's approved exploration plan, approved plan of operation, this part, and other statutes and regulations under which the refuge is administered; and perform all other duties assigned to the Regional Director by this part. The Regional Director may issue written or oral stipulations,

demands and orders to carry out his responsibilities, and amend and terminate them as he deems appropriate. Any oral stipulation, demand or order shall be confirmed in writing within 3 working days from its issuance.

§ 37.42 Inspection and monitoring.

The Regional Director may designate field representatives, hereinafter known as Field Monitors, to monitor the exploratory activities in the field. The Field Monitors may exercise the full authority of the Regional Director, provided that any stipulation, demand or order issued by a Field Monitor which modifies an existing provision of a permittee's approved plan of operation or approved exploration plan shall, except in emergencies, require the concurrence of the Regional Director. The Regional Director shall have a continuing right of access to any part of the exploratory activities at any time for inspection or monitoring and for any other purpose that is consistent with this part. A permittee, upon request by the Regional Director, shall furnish lodging, food, and reasonable use of its communication and surface and air transportation systems, to the Field Monitors and other representatives of the United States for the purposes of inspecting and monitoring the permittee's exploration activities in the field and for any other purpose consistent with this part. Whenever possible, the Regional Director shall give advance written notice of

the need for such services and facilities, including the names of persons to be accommodated.

§37.43 Suspension and modification

If at any time while exploratory activities are being carried out under an approved exploration plan and special use permit, the Regional Director, on the basis of information available to him, determines that continuation of further activities under the plan or permit will significantly adversely affect the refuge's wildlife, its habitat, or the environment, or significantly restrict subsistence uses, that such activities are no longer necessary to accomplish the objective and limitations stated in § 37.1, or that the permittee has failed to comply with its approved exploration plan, plan of operation, special use permit, any reasonable stipulation, demand or order of the Regional Director, or any regulation of this part, the Regional Director may, without any expense or liability to the Department, suspend activities under the plan and/or permit for such time, or make such modifications to the plan and/or permit, or both suspend and so modify, as he determines necessary and appropriate. Such suspensions shall state the reasons therefore and be effective immediately upon receipt of the notice. Suspensions issued orally shall be followed by a written notice confirming the action within 3 days, and all written notices will be sent by messenger or registered mail, return receipt requested. A suspension shall remain in effect until the basis for the suspension

has been corrected to the satisfaction of the Regional Director. For good cause, the Regional Director may also grant at the permittee's request, a written waiver of any provision of its special use permit, so long as such waiver will not be likely to result in significant adverse effects on the refuge's resources. Reconsideration of the Regional Director's actions under this section may be obtained by employing the procedures described in § 37.22(c). A request for reconsideration shall not operate to stay the Regional Director's actions unless such stay is granted in writing by the Director.

§ 37.44 Revocation and relinquishment.

For nonuse, for failure to comply with § 37.14, or for any action of the permittee not consistent with this part, the Regional Director may revoke or a permittee may relinquish a special use permit to conduct exploratory activities at any time by sending to the other a written notice of revocation or relinquishment. Such notice shall state the reasons for the revocation or relinquishment and shall be sent by registered mail, return receipt requested, at least 30 days in advance of the date that the revocation or relinquishment will be effective. Revocation of a permit to conduct exploratory activities shall not relieve the permittee of the obligation to comply with all other obligations specified in this part and in its special use permit, approved exploration plan and approved plan of operation. Reconsideration of the Regional Director's actions under this

section may be obtained by employing the procedures described in § 37.22(c). A request for reconsideration shall not operate to stay the Regional Director actions unless such stay is granted in writing by the Director.

§ 37.45 Exploration by the U.S. Geological Survey.

Notwithstanding the requirement found in § 37.21(b) on when exploration plans shall be submitted, the U.S. Geological Survey may at any time apply for a special use permit to conduct exploratory activities by submitting for approval one or more exploration plans in accordance with the requirements of this part and the Act. No plan submitted by the Survey will be approved unless (1) no other person has submitted a plan for the area involved which satisfies the regulations of this part and (2) the information which would be obtained from the Survey is needed to make an adequate report to Congress pursuant to the Act. Sections 37.13, 37.14, 37.46, and 37.47 shall not apply to the Survey. If authorized to conduct exploratory activities, the Survey shall comply with this part in all other respects.

§ 37.46 Cost reimbursement.

(a) Each applicant for or holder of a special use permit issued under this part shall reimburse the Department for its actual costs incurred, including, but not limited to, its direct costs and

indirect costs as established by the indirect cost rate of the charging bureau or office, in publishing, reviewing (which includes, but is not limited to, conducting any public hearings thereon), modifying, and approving or disapproving the applicant's or permittee's exploration plan(s); reviewing and approving or disapproving the permittee's summary statement, if any, under § 37.13; preparing and issuing the permittee's special use permit(s); reviewing and approving or disapproving the permittee's plan(s) of operation; inspecting, monitoring, and enforcing the permittee's compliance with its approved exploration plan(s), plan(s) of operation, special use permit(s) and this part; performing the permittee's obligations pursuant to § 37.31(a); and identifying, evaluating and preserving historic, archeological and cultural resources in areas to be explored by the permittee; as further delineated by the Regional Director.

(b) Each applicant shall submit with each exploration plan submitted a payment, the amount of which shall be an estimate made by the Regional Director of the costs which will be incurred by the Department in publishing, reviewing, modifying and approving or disapproving the applicant's exploration plan.

(1) If the applicant's plan is disapproved or if the applicant withdraws its application before a decision is reached on its plan, the applicant shall be responsible for such costs incurred by the Department in processing the applicant's application up to the date on which the plan is disapproved or the Regional Director

receives written notice of the applicant's withdrawal, and for costs subsequently incurred by the Department in terminating the application review process. If the costs actually incurred exceed the estimate paid at the time of application, reimbursement by the applicant of such additional costs shall be due within 30 days of receiving notice from the Regional Director of the additional amount due. If the actual costs incurred are less than the estimate paid by the applicant, the excess shall be refunded to the applicant.

(2) If the applicant's plan is approved, the applicant shall pay an estimate made by the Regional Director of the costs which will be incurred by the Department in preparing and issuing to the applicant a special use permit. The first quarterly payment made by the applicant pursuant to subsection (c) of this section will be adjusted upward or downward, as warranted, to accurately reflect the actual costs incurred by the Department in processing the permit.

(3) When two or more applications are filed which the Regional Director determines to be in competition with each other, each applicant shall reimburse the Department for such actual costs incurred in processing its exploration plan and special use permit, if issued, except that those costs which are not readily identifiable with one of the applicants, shall be paid by each of the applicants in equal shares.

(c) Upon issuance of a special use permit, the permittee shall make an initial advance payment covering that current fiscal year

quarter and quarterly payments thereafter to cover the actual costs incurred by the Department in administering the permittee's permit or any special use permit(s) subsequently issued to the permittee for the duration of the exploration program covered by this part. Such costs shall include, but are not limited to, those direct costs and indirect costs, as established by the indirect costs rate of the charging bureau or office, incurred in reviewing and approving the permittee's plan(s) of operation; reviewing and approving or disapproving the permittee's summary statement, if any, under § 37.13; preparing and issuing the permittee's special use permit(s); inspecting, monitoring, and enforcing the permittee's compliance with its approved exploration plan, plan(s) of operation, special use permit(s) and this part; performing the permittee's obligations pursuant to § 37.31(a); and identifying, evaluating and preserving historic, archeological and cultural resources in areas to be explored by the permittee. Each quarterly payment will be paid at the outset of the quarter and will cover the estimated cost of that quarter as adjusted by the Regional Director by reason of any adjustment warranted by subsection (b) of this section or by overpayments or underpayments in previous quarters for which adjustment has not already been made. Upon conclusion of the exploration program or termination of the permittee's special use permit, whichever is later, reimbursement or refundment of any outstanding amounts due the Department or the permittee shall be made within 180 days.

(d) Estimates required by this section shall be made by the Regional Director on the basis of the best available cost information. However, reimbursement shall not be limited to the Regional Director's estimate if actual costs exceed projected estimates.

(e) All payments required by this subsection shall be made payable to the Service. No applicant or permittee shall set off or otherwise deduct any debt due to or any sum claimed to be owed to it by the United States from any payment required by this section. Overpayments shall be credited or refunded to the person making them.

(f) When through partnership, joint venture or other business arrangement more than one person applies for or participates in a special use permit, each shall be jointly and severally liable for reimbursing the Department's costs under this section.

(g) Any lodging, food, communication, and transportation provided by a permittee under § 37.42 shall be deemed to be costs paid to the Department in kind for services rendered in inspecting and monitoring the permittee's exploratory activities. At the end of each quarter, the permittee shall furnish the Regional Director with a report, in a format approved or prescribed by him, on the goods and services provided during that quarter, and the names of the individuals to whom they were provided.

(h) Any dispute between an applicant or permittee and the Regional Director as to costs actually incurred by the Department and charged to the applicant or permittee shall be finally decided for the Secretary by the Director, using the procedures described in § 37.22(c).

§ 37.47 Civil penalties.

(a) This section prescribes the procedures for assessing a civil penalty for the violation of any provision of an approved exploration plan, any term or condition of the special use permit issued under § 37.23, or any prohibition contained in this part. The civil penalty remedy afforded by this section is in addition to all other remedies available to the Secretary.

(b) Notice of violation. (1) The notice of violation shall be issued by the Solicitor and served personally or by mail upon the person named in the notice (hereinafter the respondent). The notice shall contain:

(A) A summary of the facts believed to show a violation by the respondent;

(B) A specific reference to the provision, term, condition or prohibition allegedly violated; and

(C) The amount of the penalty proposed to be assessed. The notice may also contain an initial proposal for compromise or settlement of the action.

(2) The notice of violation shall also advise respondent of his right to:

(A) Respond to the notice within 45 calendar days from the date of its issuance by:

(i) Undertaking informal discussions with the Solicitor;

(ii) Accepting the proposed penalty or the compromise, if any, offered in the notice; or

(iii) Filing a petition for relief in accordance with subsection (c) of this section; or

(B) Take no action and await the Solicitor's notice of assessment. Such response must be received by the Solicitor on or before the 45th day during normal business hours at the address stated in the notice.

(3) Any notice of violation may be amended, but any nontechnical amendment will extend the running of the respondent's 45 day period for response from the date of the notice to the date of the amendment.

(4) Acceptance of the proposed penalty or the compromise, if any, stated in the notice of violation shall be deemed to be a waiver of the notice of assessment required in subsection (d) of this section and of the respondent's right to an opportunity for a hearing described in subsection (e) of this section.

(c) Petition for relief. If the respondent choses, he may ask that no penalty be assessed or that the amount be reduced and he may admit or contest the legal sufficiency of the Solicitor's charges and allegations of facts, by filing a petition for relief at the address specified in the notice within 45 calendar days from the date thereof. Such petition must be received by the Solicitor on or before the 45th day during normal business hours. The petition shall be in writing and signed by the respondent. If the respondent is a corporation, partnership, association or agency, the petition must be signed by an officer or official authorized to sign such document. It must set forth in full the legal or other reasons for the relief requested.

(d) Notice of assessment. (1) After 45 calendar days from the date of the notice of violation or any amendment thereof, the Solicitor may proceed to determine whether the respondent committed the violation alleged and to determine the amount of civil penalty to be assessed, taking into consideration the information available and such showing as may have been made by the respondent. The Solicitor shall notify the the respondent of his determinations by a written notice of assessment, which shall also set forth the basis for his determinations. The notice of assessment shall be served on the respondent personally or by mail.

(2) The notice of assessment shall also advise the respondent of his right to request a hearing on the matter in accordance with subsection (e) of this section.

(e) Request for a hearing. Within 45 calendar days from the date of the issuance of the notice of assessment, the respondent may request a hearing to be conducted on the matter in accordance with 5 U.S.C. §§ 554 through 557 by filing a dated, written request for hearing with the Hearings Division, Office of Hearings and Appeals, Department of the Interior, 4015 Wilson Blvd., Arlington, Virginia 22203. Such request must be received at this address on or before the 45th day during normal business hours. The respondent shall state the respondent's preference as to the place and date for a hearing. The request must enclose a copy of the notice of violation and the notice of assessment. A copy of the request shall be served upon the Solicitor personally or by mail at the address specified in the notice of assessment.

(f) Finality of decision. If no request for a hearing is filed in accordance with this section, the assessment stated in the notice of assessment shall be effective and constitute the final administrative decision of the Secretary on the 45th calendar day from the date of the notice of assessment. If the request for hearing is timely filed in accordance with this section, the date of the final administrative decision in the matter shall be as provided in subsection (g) or (h) of this section. When a civil penalty

assessed under this section becomes final, the respondent shall have 20 calendar days from the date of the final administrative decision within which to make full payment of the penalty assessed. Payment will be timely only if received in the Office of the Solicitor during normal business hours on or before the 20th day.

(g) Hearing. (1) Upon receipt of a request for a hearing, the Hearings Division will assign an administrative law judge who shall have all the powers accorded by law and necessary to preside over the parties and the hearing and to make decisions in accordance with 5 U.S.C. §§ 554 through 557. Notice of such assignment shall be given promptly to the respondent and to the Solicitor at the address stated in the notice of assessment. Upon notice of the assignment of an administrative law judge to the case, the Solicitor shall file all correspondence and petitions exchanged between the Solicitor and the respondent which shall become a part of the hearing record.

(2) The hearing shall be conducted in accordance with 5 U.S.C. §§ 554 through 557 and with 43 CFR Part 4 to the extent that it is not inconsistent with this part. Subject to 43 CFR § 1.3, the respondent may appear in person, by representative, or by counsel. The hearing shall be held in a location established by the administrative law judge, giving due regard to the convenience of the parties, their representatives and witnesses. Failure to appear at the time set for hearing shall be deemed a waiver of the right to a hearing and consent to the decision on the record made at the hearing. The judge shall render a written decision on the record,

which shall set forth his findings of facts and conclusions of law and the reasons therefore, and an assessment of a civil penalty if he determines that the respondent committed the violation charged.

(3) Discovery shall be obtained by employing the procedures described 43 CFR §§ 4.1130 through 4.1141. In addition, discovery of facts known and opinions held by experts, otherwise discoverable under 43 CFR § 4.1132(a) and acquired and developed in anticipation of administrative adjudication or litigation, may be obtained only as follows:

(A)(i) A party may through interrogatories require any other party to identify each person whom the other party expects to call as an expert witness, to state the subject matter on which the expert is expected to testify, and to state the substance of the facts and opinions to which the expert is expected to testify and a summary of the grounds for each opinion. (ii) Upon motion, the administrative law judge may order further discovery by other means, subject to such restrictions as to scope and such provisions under subparagraph (C) of this paragraph concerning fees and expenses, as the administrative law judge may deem appropriate.

(B) A party may discover facts known or opinions held by an expert, who has been retained or employed by another party in anticipation of administrative adjudication or litigation or preparation therefore and who is not expected to be called as a witness, only upon a showing of exceptional circumstances under which it is impracticable for the party seeking discovery to obtain facts or opinions on the same subject by other means.

(C) Unless manifest injustice would result, (i) the administrative law judge shall require the party seeking discovery to pay the expert, or the Department if the expert is an employee of the United States, a reasonable fee for time spent in responding to subparagraphs (A)(ii) and (B) of this paragraph; and (ii) with respect to discovery under subparagraph (A)(ii) the administrative law judge may require and with respect to discovery under subparagraph (B) the administrative law judge shall require, the party seeking discovery to pay the other party a fair portion of the fees and expenses reasonably incurred by the latter party in obtaining facts and opinions from the expert.

(4) Unless the notice of appeal is filed in accordance with subsection (h) of this section, the administrative law judge's decision shall constitute the final administrative decision of the Secretary in the matter and shall become effective 30 calendar days from the date of the decision.

(h) Appeal. (1) Either the respondent or the Solicitor may seek an appeal from the decision of an administrative law judge as to the respondent's violation or penalty or both by the filing of a notice of appeal with the Director, Office of Hearings and Appeals, United States Department of the Interior, 4015 Wilson Boulevard, Arlington, Virginia 22203, within 30 calendar days of the date of the administrative law judge's decision. Such notice shall be accompanied by proof of service on the administrative law judge and the opposing party.

(2) Upon receipt of such a request, the Director, Office of Hearings and Appeals, shall appoint an ad hoc appeals board to determine whether an appeal should be granted, and to hear and decide an appeal. To the extent they are not inconsistent herewith, the provisions of 43 CFR, Part 4, Subpart G shall apply to appeal proceedings under this subsection. The determination of the board to grant or deny an appeal, as well as its decision on the merits of an appeal, shall be in writing and become effective as the final administrative determination of the Secretary in the matter on the date it is rendered, unless otherwise specified therein.

(i) Amount of penalty. The amount of any civil penalty assessed under this section shall not exceed $10,000 for each violation. Each day of a continuing violation shall, however, constitute a separate offense. In determining the amount of such penalty, the nature, circumstances, extent, and gravity of the violation committed, and, with respect to the respondent, his history of any prior offenses, his demonstrated good faith in attempting to achieve timely compliance after being cited for the violation, and such other matters as justice may require shall be considered.

(h) Petition for remission. The Solicitor may modify or remit, with or without conditions, any civil penalty which is subject to imposition or which has been imposed under this subsection unless the matter is pending in court for judicial review or for recovery

of the civil penalty assessed. A petition for remission may be filed by the respondent with the Solicitor at any time from the date of the notice of violation referred to in subsection (b) of this section until 90 days after the date of final administrative decision assessing a civil penalty. The petition must set forth in full the legal and other reasons for the relief requested. Any petition that is not timely filed will not receive consideration. The Solicitor's decision shall be the final administrative decision for the Secretary on the petition.

Subpart F - Reporting and Data Management

§ 37.51 Operational reports.

(a) Each permittee shall submit bi-weekly reports on the progress of exploratory activities during the preceding 2 weeks in a manner and format approved or prescribed by the Regional Director. These shall include, but are not limited to, a daily log of operations, and a report on the discovery of any springs, hydrocarbon seeps, and other unusual phenomena.

(b) Each permittee shall submit to the Regional Director a semiannual report of exploratory activities conducted within the periods from December through May and June through November. These semiannual reports shall be submitted on July 1 and January 1 and shall contain the following:

(1) A description of the work performed;

(2) Charts, maps, or plats depicting the areas in which any exploratory activities were conducted, specifically identifying the seismic lines and the locations where geological exploratory activities were conducted, and the locations of campsites, airstrips and other support facilities utilized;

(3) The dates on which exploration was actually performed.

(4) A narrative summary of any: (A) surface occurrences of hydrocarbon or environmental hazards, and (B) adverse effects of the exploratory activities on the refuge's wildlife, its habitat, the environment, cultural resources, or other uses of the area in which the activities were conducted; and

(5) Such other information as may be reasonably specified by the Regional Director.

(c) Each permittee shall also submit such other reports as are specified in this part.

§ 37.52 Records.

The permittee shall keep accurate and complete records relating to its exploratory activities and to all data and information, including, but not limited to, raw, processed, reprocessed, analyzed and interpreted data and information, obtained as a result thereof. Until September 2, 1989, the Secretary shall have access to and the right to examine and reproduce any records, papers, or other

documents relating to such activities, data and information in order to ascertain the permittee's compliance with this part, ability to perform under any special use permit, and reliability and accuracy of all data, information and reports submitted to the Regional Director.

§ 37.53 Submission of data and information.

(a) The permittee shall submit to the Regional Director free of charge all data and information obtained as a result of carrying out exploratory activities. Such data and information include, but are not limited to, copies of all original observations and recordings made in written or electronic form during field operations and copies of all data and information which results from any subsequent modification, processing, analysis, or interpretation thereof or of samples obtained during field operations by human or electronic means on or off the refuge. The permittee shall submit such data and information within 30 days after the end of the month during which they become available to it at every level of data gathering or utilization, i.e., acquisition, processing, reprocessing, analysis, and interpretation.

(b) Each submission of geophysical data or information shall contain, unless otherwise specified by the Regional Director, the following:

(1) An accurate and complete record of each geophysical survey conducted under the permittee's permit, including digital navigational data and final location maps of all survey stations; and,

(2) All seismic data developed under permit, presented in a format and of a quality suitable for processing.

(c) Processed geophysical information shall be submitted with extraneous signals and interference removed, and presented in a format and of a quality suitable for interpretive evaluation, reflecting state-of-the-art processing techniques.

(d) Processed, analyzed and interpreted data or information required to be submitted by the Act and this section shall include, but not be limited to, seismic record sections, and interpretations thereof; geologic maps, cross sections, and interpretations thereof; maps of gravitational and magnetic fields and interpretations thereof; and chemical or other analyses of rock samples collected on the refuge and interpretations thereof.

(e) If the permittee proposes to transfer any data or information covered by this section to a third party or the third party proposes to transfer such data or information to another third party, the transferor shall notify the Regional Director at least 10 days in advance and shall require the receiving third party, in writing, to abide by the obligations of the permittee as specified in this section as a condition precedent to the transfer of such data or information.

§ 37.54 Disclosure.

(a) The Department shall make raw data and information obtained as a result of carrying out exploratory activities and submitted by the permittee or a third party available to the public in accordance with the Act and the procedural requirements of the Freedom of Information Act, 5 U.S.C. § 552, and 43 CFR Part 2. Until 2 years after any lease sale including the area within the refuge from which such data or information were obtained, the Department shall withhold from the public all processed, analyzed and interpreted data or information obtained as a result of carrying out exploratory activities and submitted by the permittee or a third party, if they have been properly marked and correctly identified in accordance with subsection (b), by invoking subsection (e)(2)(C) of the Act and exemption 3 to the Freedom of Information Act, 5 U.S.C. § 552(b)(3). Thereafter, the Department shall treat such data or information as raw data and information. The Department shall make all other records submitted by a permittee or a third party relating to the activities covered by Acts this part available to the public in accordance with the Freedom of Information Act, 5 U.S.C. § 552, and 43 CFR Part 2.

(b) Any permittee or other person submitting processed, analyzed and interpreted data or information to the Regional Director shall clearly identify them by marking the top of each page bearing such data or information with the words "PROCESSED, ANALYZED

AND INTERPRETED DATA OR INFORMATION". All pages so marked shall be physically separated by the person submitting them from those not so marked, unless doing so will destroy the value or integrity of the data or information presented. In that event, the document submitted will be accompanied by a summary identifying the location of all processed, analyzed and interpreted data or information which are not segregated, and explaining the reasons therefore. All pages not marked with this legend and all other data and information incorrectly identified as bearing such data or information shall be available to the public upon request. The Department reserves the right to determine whether any page so marked is correctly identified.

(c) The Department reserves the right to disclose any processed, analyzed and interpreted data or information obtained from a permittee or a third party to an agent or third party for the purpose of reproducing, processing, reprocessing, analyzing or interpreting such data or information, and the right to disclose any other information obtained from a permittee or a third party which may be exempt from public disclosure under the Freedom of Information Act, 5 U.S.C. § 552, to an agent or third party in order to carry out the Department's statutory authorities. When practicable, the Department shall notify the permittee who provided the data or information of its intent to disclose the data or information to an agent or third party. Prior to any such disclosure, the recipient shall be required to execute a written

commitment not to transfer or to otherwise disclose any data or information to anyone without the express consent of the Department. The recipient shall be liable for any unauthorized use by or disclosure of such data or information to other third parties.

(d) The Department reserves the right to disclose any processed, analyzed and interpreted data and information and any other confidentical information to the Congress and any committee or subcommittee of the Congress having jurisdiction over the refuge or this exploration program and to any part of the Executive and Judicial Branches of the United States for official use. The recipient shall be responsible for maintaining the confidentiality of such data and information in accordance with the Act.

Appendix I - Legal Description of Coastal Plain, Arctic National Wildlife Refuge, Alaska.

Beginning at the meander corner of section 35 on the First Standard Parallel North on the line of mean high water on the left bank of the Canning River, T.5 N., R. 23 E., Umiat Meridian;

Thence easterly, along the First Standard Parallel North, approximately 40 3/4 miles to the closing corner of T. 4 N., Rs. 30 and 31 E., Umiat Meridian;

Thence southerly, between Rs. 30 and 31 E., approximately 6 miles to the corner of Tps. 3 and 4 N., Rs. 33 and 34 E., Umiat Meridian;

Thence easterly, between Tps. 3 and 4 N., approximately 18 miles to the corner of Tps. 3 and 4 N., Rs. 33 and 34 E., Umiat Meridian;

Thence southerly, between Rs. 33 and 34 E., approximately 6 miles to the corner of Tps. 2 and 3 N., Rs. 33 and 34 E., Umiat Meridian;

Thence easterly, between Tps. 2 and 3 N., approximately 21 miles to the meander corner of sections 4 and 33, on

the line of mean high water on the left bank of the Aichilik River, Tps. 2 and 3 N., R. 37 E., Umiat Meridian;

Thence northeasterly, along the line of mean high water on the left bank of the Aichilik River, approximately 32 miles to a point at the line of mean high tide of the Beaufort Lagoon, located in section 28, T. 6 N., R. 40 E., Umiat Meridian;

Thence on an approximate forward bearing of N. 65 degrees E., approximately 7,600 feet to a point on the northerly boundary of the Arctic National Wildlife Refuge located in section 22, T. 6 N., R. 40 E., Umiat Meridian at the line of extreme low tide:

Thence northwesterly, along the northerly boundary of the Arctic National Wildlife Refuge at the line of extreme low tide on the seaward side of all offshore bars, reefs and islands, approximately 28 miles, to a point in section 33, T. 9 N., R. 36 E., that is due north of the corner of T. 8 N., Rs. 36 and 37 E., Umiat Meridian;

Thence due South, approximately 3/4 miles to the corner of T. 8 N., Rs. 36 and 37 E., Umiat Meridian;

Thence southerly between Rs. 36 and 37 E., approximately 3 miles to the corner of sections 13, 18, 19, and 24, T. 8. N., Rs. 36 and 37 E., Umiat Meridian;

Thence westerly, between sections 13 and 24, approximately 1 mile to the corner of sections 13, 14, 23 and 24, T. 8 N., R. 36 E., Umiat Meridian;

Thence northerly, between sections 13 and 14, approximately 1 mile to the corner of sections 11, 12, 13 and 14, T. 8 N., R. 36 E., Umiat Meridian;

Thence westerly, between sections 11 and 14, 10 and 15, 9 and 16, 8 and 17, approximately 4 miles to the corner of sections 7, 8, 17 and 18, T. 8 N., R. 36 E., Umiat Meridian;

Thence southerly, between sections 17 and 18, 19 and 20, 29 and 30 to the corner of sections 29, 30, 31 and 32, T. 8 N., R. 36 E., Umiat Meridian;

Thence westerly, between sections 30 and 31, approximately 1 mile to the corner of sections 25, 30, 31 and 36, T. 8 N., Rs. 35 and 36 E., Umiat Meridian;

Thence southerly, between sections 31 and 36, approximately 1 mile to the corner of Tps. 7 and 8 N., Rs. 35 and 36 E., Umiat Meridian;

Thence westerly, between Tps. 7 and 8 N., approximately 1 mile to the corner of sections 1, 2, 35 and 36, Tps. 7 and 8 N., R. 35 E., Umiat Meridian;

Thence northerly, between sections 35 and 36, 25 and 26, 23 and 24, approximately 3 miles to the corner of sections 13, 14, 23 and 24, T. 8 N., R. 35 E., Umiat Meridian;

Thence westerly, between sections 14 and 23, 15 and 22, 16 and 21, 17 and 20, 18 and 19, 13 and 24, 14 and 23, 15 and 22, 16 and 21, 17 and 20, approximately 10 miles to the corner of sections 17, 18, 19 and 20, T. 8 N., R. 34 E., Umiat Meridian;

Thence northerly, between sections 17 and 18, approximately 1 mile to the corner of sections 7, 8, 17 and 18, T. 8 N., R. 34 E., Umiat Meridian;

Thence westerly, between sections 7 and 18, approximately 1 mile to the corner of sections 7, 12, 13 and 18, T. 8 N., Rs. 33 and 34 E., Umiat Meridian;

Thence southerly, between Rs. 33 and 34 E., approximately 1 mile to the corner of sections 13, 18, 19 and 24, T. 8 N., Rs. 33 and 34 E., Umiat Meridian;

Thence westerly, between sections 13 and 24, 14 and 23, 15 and 22, approximately 3 miles to the corner of sections 15, 16, 21 and 22, T. 8 N., R. 33 E., Umiat Meridian;

Thence southerly, between sections 21 and 22, approximately 1 mile to the corner of sections 21, 22, 27 and 28, T. 8 N., R. 33 E., Umiat Meridian;

Thence westerly, between sections 21 and 28, approximately one mile to the corner of sections 20, 21, 28 and 29, T. 8 N., R. 33 E., Umiat Meridian;

Thence southerly, between sections 28 and 33, 29 and 32, approximately 2 miles to the corner of sections 4, 5, 32 and 33, Tps. 7 and 8 N., R. 33 E., Umiat Meridian;

Thence westerly, between Tps. 7 and 8 N., approximately 2 miles to the corner of Tps. 7 and 8 N., Rs. 32 and 33 E., Umiat Meridian;

Thence southerly, between sections 1 and approximately 1 mile to the corner of sections 1, 6, 7, and 12, T. 7 N., Rs. 32 and 33 E., Umiat Meridian;

Thence westerly, between sections 1 and 12, approximately 1 mile to the corner of sections 1, 2, 11 and 12, T. 7 N., R. 32 E., Umiat Meridian;

Thence northerly, between sections 1 and 2, 35 and 36, approximately 2 miles to the corner of sections 25, 26, 35 and 36, T. 8 N., R. 32 E., Umiat Meridian;

Thence westerly, between sections 26 and 27, 34 and 35, approximately 2 miles to the corner of sections 27, 28, 33 and 34, T. 8 N., R. 32 E., Umiat Meridian;

Thence southerly, between sections 33 and 34, approximately one mile to the corner of sections 3, 4, 33 and 34, Tps. 7 and 8 N., R. 32 E., Umiat Meridian;

Thence westerly, between Tps. 7 and 8 N., approximately 3 miles to the corner of Tps. 7 and 8 N., Rs. 31 and 32 E., Umiat Meridian;

Thence northerly, beween 31 and 32 E., approximately 3 1/2 miles to a point on the northerly boundary of the Arctic National Wildlife Refuge at the line of extreme low tide located between sections 13 and 18, T. 8 N., Rs. 31 and 32 E., Umiat Meridian;

Thence westerly, along the northerly boundary of the Arctic National wildlife Refuge approximately 57 miles along the line of extreme low water of the Arctic Ocean, including all offshore bars, reefs, and islands, to the most westerly tip of the most northwesterly island, westerly of Brownlow Point, section 6, T. 9 N., R. 25 E., Umiat Meridian;

Thence on an approximate forward bearing of S. 56 1/2 degree W. approximately 3 1/4 miles to the mean high water line of the extreme west bank of the Canning River in section 15, T. 9 N., R. 24 E., Umiat Meridian;

Thence southerly, along the mean high water line of the west bank of the Canning River approximately 32 miles to the meander corner on the First Standard Parallel North at a point on the southerly boundary of section 35, T. 5 N., R. 23 E., Umiat Meridian, the point of beginning.

APPENDIX B

SOILS, VEGETATION AND ENVIRONMENTAL MAPPING

SOILS AND TERRAIN ASSOCIATIONS OF THE FOOTHILLS AND COASTAL PLAIN PORTION OF THE ARCTIC NATIONAL WILDLIFE REFUGE

By K. R. Everett

INTRODUCTION

Soil as used in this report refers to the August active layer. Nomenclature used is that of the U.S. Department of Agriculture, Soil Conservation Service Manual 430, 1981 Draft and Handbook 436 (Soil Taxonomy, 1975) unless otherwise noted. (See table III-2.)

To date, no detailed regional soil survey exists for any portion of Alaska north of the Brooks Range, with the exception of the Prudhoe Bay production area (D. A. Walker and others, 1980) and the Ogotoruk Creek watershed (Holowaychuk and others, 1966). In 1962, Brown developed a soils-landform map for approximately 19 square kilometers in the Okpilak Lakes area and described soils along Jago and Hulahula Rivers. In 1974, Janz described, in the course of route selection studies for Alaskan Arctic Gas Study Company, several soils from the foothills near the Kongakut, Aichilik, and Okerokovik Rivers and from the flood plain of the Canning River. (See fig. B-1.)

The information presented in the following sections was derived from a number of sources including a ground-truth reconnaissance survey in 1981. From that survey, which used color infrared photographs (1:60,000), the soil landform key was developed. (See table III-2; fig. III-3; and pls. 1 and 2.)

With the exception of discontinuous areas of flat, lake-dotted coastal plain between the Hulahula River and Pokok Bay and the northern portion of the Canning River Delta east to the delta of the Katakturuk, the portion of the wildlife refuge under study is composed of rolling uplands. The majority of the area is designated as belonging to the White Hills section of the coastal plain (Wahrhaftig, 1965; fig. III-2). That area between the Canning River and the Katakturuk, in particular, is physiographically and geologically similar to the White Hills area in the Franklin Bluffs region. The majority of the study region is probably best described as Foothills.

Regardless of its final physiographic designation, the area to which the following sections apply is characterized by rounded, north-trending interfluves between major drainages. Elevations range from 90 m at the coastward boundary to about 375 m at the southern limit of the province. These major interfluves are subdivided into a finer textured pattern of subparallel drainages. Superimposed on the north-south pattern is one that trends generally east-west, reflecting the strike of the underlying Cretaceous or Tertiary sandstones and shales. Outcrops of some of the flatter lying, more competent units produce mesalike elements on the interfluves, whereas the north-dipping strata produce discontinuous linear trends.

It is likely that at least the southern parts of the north-trending interfluves were sculptured by early Pleistocene glaciers advancing from the Brooks Range. Although moraines associated with the later ice advances can be found near the mountain front, the extent of ice-deposited materials on the interfluves is

Figure B-1.--Extent of the Arctic National Wildlife Refuge shown by shaded area. Coastal Plain Land Resource Region shown with principal soil associations are shown: MAI, Pergelic Cryaquolls-Histic Pergelic Cryaquepts; IQ22, Pergelic Cryaquepts. Foothills Land Resource Region is bounded by heavy lines. Modified from Rieger and others, 1979.

uncertain. The extent to which the area has been inundated by interglacial marine transgressions is also unclear, but it seems likely that such deposits may extend a considerable distance inland, especially east of the Okpilak River.

Nearly the entire area of the wildlife refuge being considered here falls within the Coastal Plain Land Resource Region as defined in the Exploratory Soil Survey of Alaska (Rieger and others, 1979; fig. B-1). Within this region the survey recognized two soil associations; i.e., "segments of the landscape with a distinctive topographic and soil pattern": (1) Pergelic Cryaquolls-Histic Pergelic Cryaquepts, with loamy textured mineral components occurring on nearly level to rolling topography--the broad, smooth north-trending interfluves and flat near-coastal areas with oriented lakes (fig. B-1). (2) Pergelic Cryaquepts on nearly level topography with very gravelly mineral components--the braided river valleys and their associated terraces and deltas.

In the following sections five regionally significant terrain types are considered. (See fig. III-3.) They correspond to those used in the descriptions of the Landsat landcover categories (pl. 1).

RIVERINE TERRAIN TYPE

This consists of the active channel and usually one or more terraces (fig. B-2). The majority of the major rivers within the part of the wildlife refuge being considered here have braided channels ranging in width from about 1 km to 4 km. Most of the diamond-shaped islands between channels are probably inundated at least sporadically in most years during the period of meltoff (usually late May to early June). Two types of islands can be recognized. Those consisting of unvegetated gravels and gravelly sands (or silts in the delta region) that have numerous scour pits. No soil development is recognized on these features, and they are described simply as river wash (table B-1). Other islands now spatially and recently removed from the main channel or elevated slightly above the normal high-water mark because of channel cutting have widely ranging vegetation coverage, depending upon the extent and frequency of inundation. The soils consist of various thicknesses of silt, silt loam, loam, and fine sandy loam over gravel and gravelly sands. In the most stable positions, a thin A_1 horizon has developed and some mottling occurs in the fine sediments. The active layer normally exceeds 1 m. The soils are classified as Cryorthents. Most islands are complexes of Cryorthents and river wash. In a few cases where fine sandy surface sediments have been reworked into low discontinuous sand dunes, Cryopsamment soils are recognized. Permafrost is in excess of 1 m or may be absent.

The youngest of the terraces commonly retain the relict pattern of channels and islands. For the most part, soils of the islands are Cryorthents and are well drained. The overlying fine materials may be 20 cm or more thick and are commonly bedded. The coarser layers are composed of fine sands (fig. B-3). An organic-rich surface (A) horizon may be from a few to 15 cm thick. The channel areas are poorly to very poorly drained with fibrous organic O horizons up to 20 cm or more thick overlying mottled gray silt and silt loam-textured materials. Permafrost is encountered usually within 0.5 m. These soils are Pergelic Cryaquepts. A surface pattern, consisting of 1- to 2-m-diameter polygon cells, is common to the better drained island elements. Other of the terraces may lack any surface pattern and consist mostly of wet graminoid tundra, while others may have weakly expressed (disjunct) polygons and strangmoor.

Table B-1.--Terrain types and principal soils within the Arctic National Wildlife Refuge

		Mesoscale	Microscale*		Soil
I	Riverine	(1) Terrace	(1) High-centered polygons (t)	Inceptisols	(1) Pergelic Cryaquepts
		(2) River Island Complex	(2) Low-centered polygons (t)		(2) (Sapric) Histic Pergelic Cryaquepts
		(3) Bluff and Bluff edge	(3) Mixed high- and low-centered polygons (t)		(3) (Fibro/hemic) Histic Pergelic Cryaquepts
II	Thaw-Lake Plain	(1) Thaw-Lake Complex	(4) Disjunct polygons	Histosols	(4) Pergelic Cryosaprists
		(2) Drained lake basin (> 4 ha)	(5) Frost boils (r)		(5) Pergelic Cryofibrists
		(3) Flat	(6) Strangmoor		(6) Pergelic Cryohemists
		(4) Pond Complex	(7) Water tracks		(7) Pergelic Cryaquolls
III	Foothills	(1) Crest/interfluve	(8) Reticulate (c)	Mollisols	(8) Histic Pergelic Cryaquolls
		(2) Slope (> 2%)	(9) Featureless		(9) Ruptic-Entic Pergelic Cryaquolls
		(3) Stream Complex	(10) Solifluction and/or mudflow		(10) Pergelic Cryoborolls
		(4) Flat	(11) Scour pits	Entisols	(11) Pergelic Cryorthents (Fluventic) Pergelic Cryorthents
		(5) Drained lake basin			(12) Cryosamments
IV	Alpine	(1) Crest		Non-Soils	
		(2) Slope (> 10%)			(13) Riverwash
		(3) Flat			(14) Rock
V	Rolling Coastal Plain	(1) Crest/interfluve			
		(2) Slope (> 2%)			
		(3) Thaw-Lake Complex			
		(4) Pond Complex			
		(5) Drained lake basin (> 4 ha)			
		(6) Flat			

* (t) = thermokarst; (r) strips; (c) channels.

Note: Combinations of the above characterizing elements are to be used within the landcover classes defined on plates 1 and 2.

Figure B-2.--Riverine terrain, showing river island complex. Light areas (arrow 1) are river-wash gravelly sands and lack vegetation and soils. Darker areas (arrow 2) have vegetation and Pergelic Cryorthent soils (fig. B-3). Terraces that are generally above high-water inundation (arrow 3) may have Pergelic and Histic Pergelic Cryaquepts associated with some form of ground pattern. High bluffs with Pergelic Cryaquoll soils parallel the river on the south and west side (arrow 4). Photograph by K. R. Everett, Institute of Polar Studies, The Ohio State University.

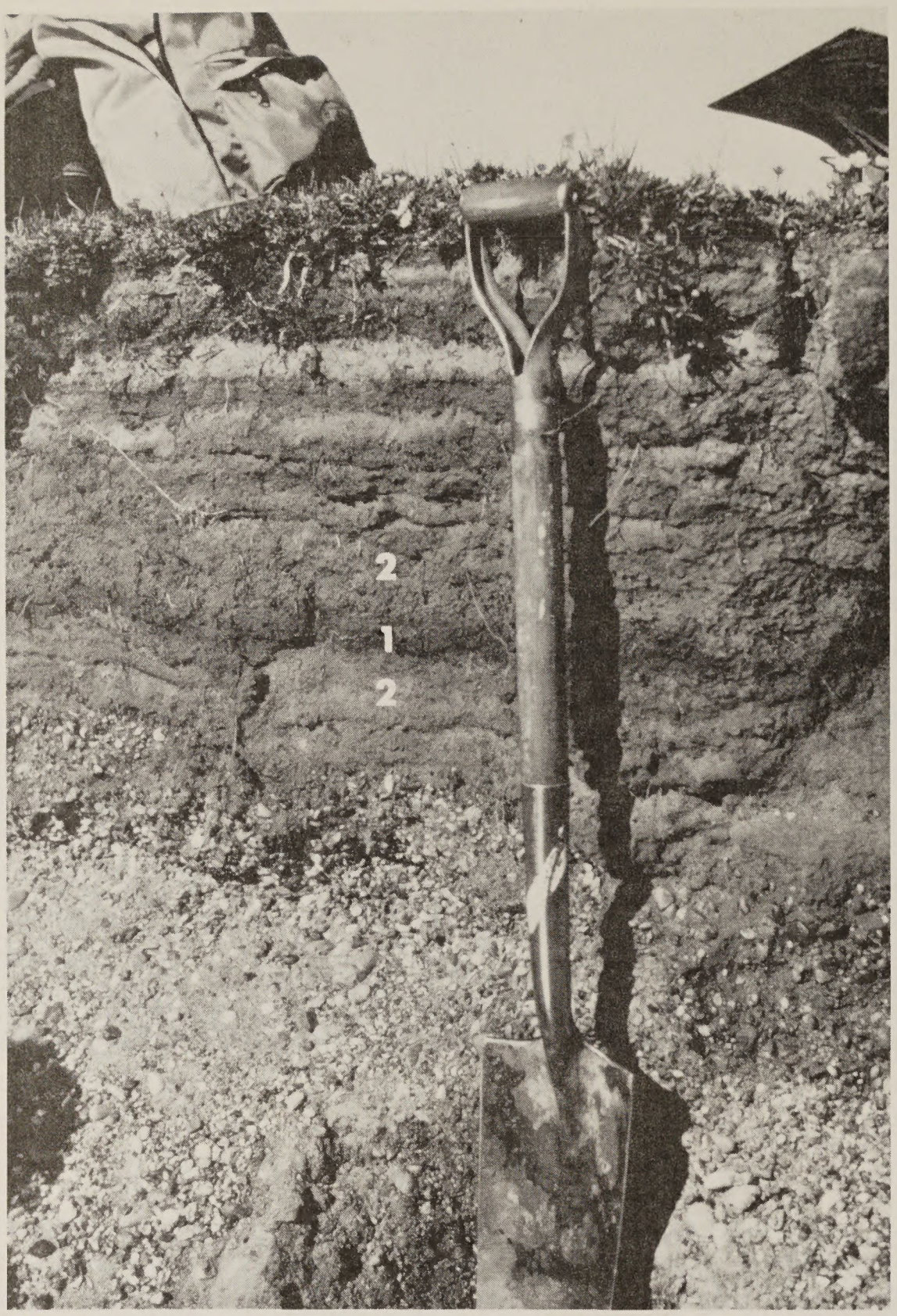


Figure B-3.--Pergelic Cryorthent developed in a well-drained river terrace. Upper 50 cm of this profile displays a series of interbedded organic-rich silts and/or fine sands (1) with similar materials low in organic matter (2). Light-colored bands in the upper 20 cm possibly represent aeolian sands. Photograph by K. R. Everett, Institute of Polar Studies, The Ohio State University.

Summer vehicle impact may be extensive in the moist and wet components of the landscape. In these cases, the soils are Pergelic Cryaquepts and occasionally Histic Pergelic Cryaquepts. Outward from the river the trend in soil and ground pattern development is toward the establishment of a shallow active layer, poor and very poor drainage with Cryorthents and Fluvent-like soils giving way to Pergelic and Histic Pergelic Cryaquepts in which the surface organic horizon is composed of fibrous sedge peat and roots. Disjunct low-centered polygons and/or strangmoor mask the relict river island pattern. Soils of the Riverine areas are with few exceptions near neutral to moderately alkaline in reaction (pH). This is true even of the more organic-rich soils on the higher terraces since they receive frequent additions of alkaline loess.

Steep bluff slopes (24 to 30 percent) marginal to the rivers and a narrow strip along their crests are included within the Riverine system (fig. B-4). Bluffs may be undergoing active erosion or they may be fossil, in the sense that they rise above ancient river terraces. In either case, they are subject to rapid natural failure by mudflow or by solifluction. The result is commonly a complex of soils (and non-soil) on which the solifluction lobes which may stand 50 cm or more above the surrounding slope, exhibit over-thickened (cumulic) A horizons. Wetter areas occur upslope from and behind the lobes. In either case, the soils are Pergelic Cryaquolls.

The topographic contrast associated with this bluff produces a micro-topographic reversal of former low-centered polygons. (See Brown and others, 1980.) During the course of this reversal, the low, highly organic rich centers (often Pergelic Cryaquepts or Histic Pergelic Cryaquepts) undergo oxidation. Commonly, the soils are enriched with mineral materials eroded from the exposed bluff or derived from the river island complex below. The resulting soils are well-drained Pergelic Cryaquolls or, in some cases, Pergelic Cryoborolls. The organic-rich surface horizons are underlain by variable thicknesses of oxidized sandy textured materials that thaw to depths of 1 m or more. The processes of topographic reversal are quickly attenuated inland from the bluff edge and, generally within a distance of 100-m low-centered polygons (or some other surface pattern), are well developed. The addition of windblown fine sand can usually be recognized for distances well beyond 100 m.

Bluff crests and their soils undergo natural profile disruption by congeliturbation and by wind abrasion. By virtue of their exposed position they are commonly snow free during winter and are always susceptible to damage by vehicles which can lead to increased wind abrasion and erosion should the turfy A horizon be broken. The natural instability of the bluff face indicates it is probably very susceptible to outside disturbances, especially those that induce channeling or ponding of melt waters. Fig B-4 summarizes mesoscale landforms and soils.

FOOTHILLS TERRAIN TYPE

The bulk of the ANWR under consideration falls under the above heading. Interfluves throughout much of the area are elongate convex features (figs. B-5, B-6) or nearly flat mesalike forms. In either case the crests are commonly sites of complex patterns of soils and microscale landforms (figs. B-7, B-8): e.g., areas of tussock-covered high-centered polygons juxtaposed with patternless areas, strangmoor, and low-centered polygons. Thermokarst pits are a common adjunct and reflect substantial amounts of wedge ice. The soils of the better drained moist elements of the landscape--the raised-centered polygons--are Cryaquolls with up to

Moisture Status (%) W-wet, M-moist, D-dry

+ Term is not currently recognized in U.S. Soil Taxonomy

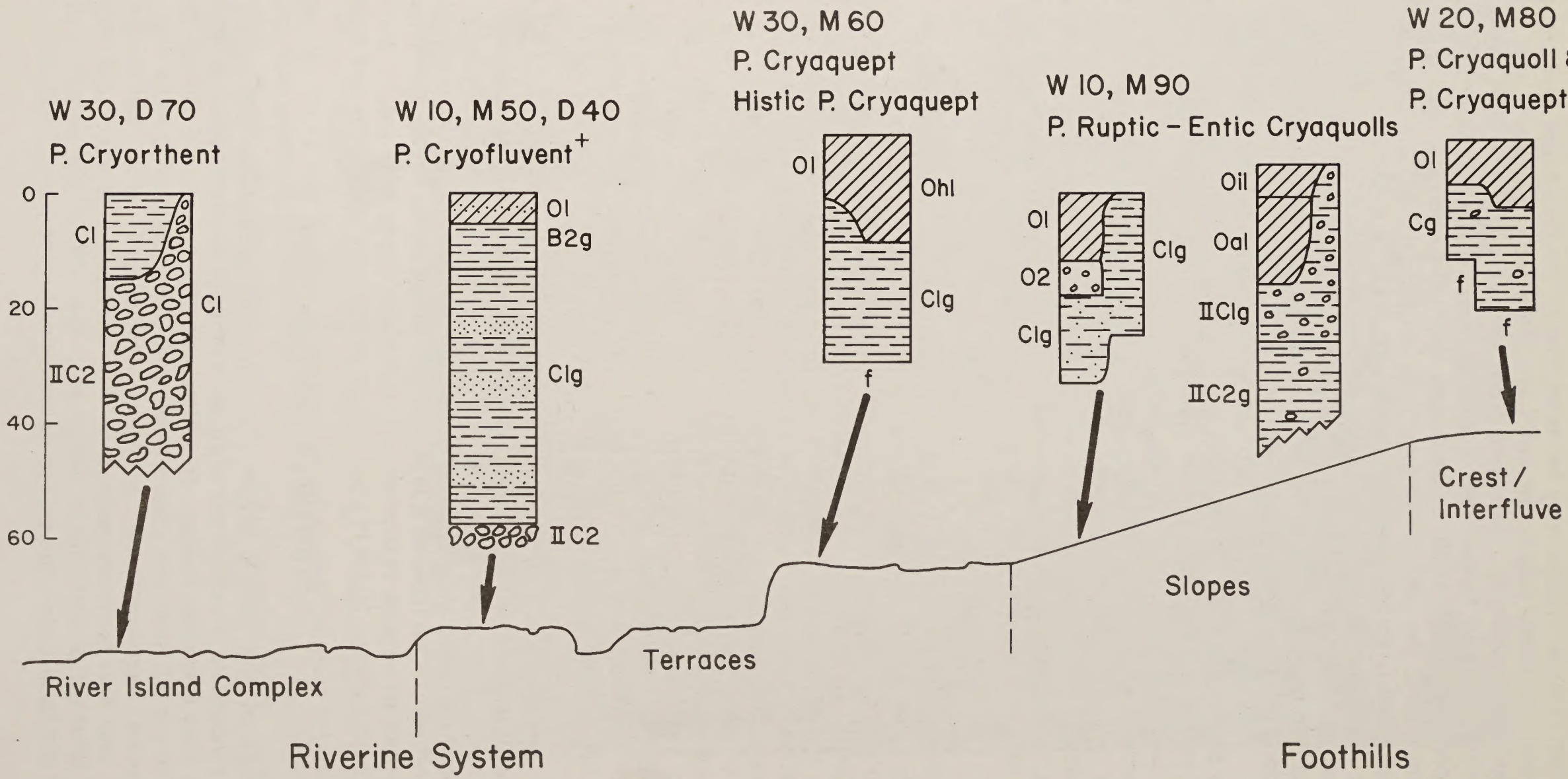


Figure B-4.—Idealized Toposequence Across Riverine and Foothills Terrain Type, Arctic National Wildlife Refuge

Figure B-5.--Flat to gently sloping mesalike interfluve typical of the Foothills terrain type (arrow 1). Flat crest areas commonly show thermokarst (fig. B-7). Three to five percent slopes above escarpment have sedge tussock tundra (landcover units VI or VII; arrow 2). Soils are Pergelic Ruptic-Entic Cryaquolls and Pergelic Cryaquepts. Ice-wedge polygons are weakly expressed. Solifluction slopes below escarpment are prone to failure by mudflow (arrow 3). Soils are complexes of Pergelic Cryaquepts and Histic Pergelic Cryaquepts. Slope in immediate foreground is sedge tussock tundra above solifluction slope. Photograph by K. R. Everett, Institute of Polar Studies, The Ohio State University.

Figure B-6.--A barrens composed of gravelly fine sandy loam reflecting the proximity of bedrock. Frost scars on the crest are translated to discontinuous stripes on the slope. Soils are either not identified or are Pergelic Cryorthents. Histic Pergelic Cryaquepts are common to the solifluction slope associated with the snowbank area (arrow 1). Sedge tussock slopes with Pergelic Ruptic-Entic Cryaquolls lead away from ridge (arrow 3). Moist/wet sedge tundra complex is seen in valley head (arrow 2). (See fig. B-7.) Photograph by K. R. Everett, Institute of Polar Studies, The Ohio State University.

Figure B-7.--Foothills terrain type, Landsat cover category IV, moist/wet sedge tundra complex developed in crest position. Dark areas are moist raised- or flat-centered polygons. Thermokarst (seen in the lower third of photograph) is prominent on many crest areas and drainage heads. Photograph by K. R. Everett, Institute of Polar Studies, The Ohio State University.

Figure B-8.--Pergelic Cryaquolls (right profile), the upper 8 cm (1) of which is highly decomposed (Sapric) organic matter. The remainder of the profile (2) consists of dark-colored organic-rich loam/fine sandy loam. Pergelic Cryaquepts (left profile); below the uppermost 5 cm of moderately decomposed organic material (1) there is approximately 20 cm of gray, mottled loam/fine sandy loam (2). Similarly textured mineral soil below (3) has enmixture of fibrous organic materials. Photograph by K. R. Everett, Institute of Polar Studies, The Ohio State University.

12 cm of Hemic or Sapric organic matter overlying dark-colored organic-rich mineral material; Cryaquepts occur as frost scars that may occupy up to 40 percent of the polygon surface. (See fig. B-9.) Mineral horizons of both soils are loams or fine sandy loams with variable amounts of pebbles. Active layer thickness ranges from near 30 cm beneath the Aquolls to greater than 60 cm beneath the Aquepts. A water table is absent or well below the surface. The wet areas commonly have Histic (greater than 20 cm of fibrous organic) Pergelic Cryaquolls or Histic Pergelic Cryaquepts if colors (and organic carbon content) below the histic epipedon do not conform to the criteria for the mollic epipedon. In either case, a water table occurs at or above the surface, and permafrost is between 40 and 45 cm. In the wettest areas there is enough bouyancy in the fibrous organic-root-rich mat that its true thickness is difficult to determine.

Relatively dry areas which include prominent (greater than 50 cm high) rims of low-centered polygons and some high-centered polygons have Histic Pergelic Cryaquolls with a Sapric organic horizon. Permafrost is generally between 20 and 30 cm, and no water table develops.

The proportion of dry, moist, wet, and very wet areas of the flat or concave crest landscape varies considerably; however, the moist tundra generally exceeds 30 percent (70 percent if the tussock areas are included); wet to very wet, 10 to 20 percent; and dry, 10 to 20 percent.

Other interfluves are mostly convex in shape (fig. B-10). Narrow central or crestline depressions similar to the more extensive ones just described are common. These crests give way to tussock slopes (greater than 5 percent). Parallel and subparallel water tracks are commonly present, giving the topography a decidedly ribbed appearance. Areas referred to as water tracks are shallow vegetated channels that conduct snowmelt waters and perhaps subsurface waters as well during the thaw season. Strangmoor is often found in the channels, suggesting slow mass movement of the saturated soil column. Willow and birch are concentrated in these features and impart distinct color patterns on color infrared photographs in summer and on standard color film in the fall. The inter-water-track areas are tens to hundreds of meters wide, convex to the adjoining track and from 0.15 to 1 m above the track. Vegetation is characterized by tussocks of Eriophorum vaginatum. Willow and/or birch commonly are a significant component of the vegetation but are spread out. Frost scars are almost always a component of tussock tundra and can comprise up to 50 percent of a given surface, with anywhere from a few percent to 75 percent showing some activity (i.e., having bare mineral soil exposed). It is a common occurrence where slope breaks occur that both the density and activity of frost scars increase (fig. B-10). In such cases, 65 to 80 percent of the surface may be comprised of active frost scars. Tussocks are generally absent and grasses, especially Arctogrostis latifolia are common. Where bedrock is very close to the surface, as shown in figure B-6, frost scars and/or patterned lag gravel may comprise 70 to 80 percent of the surface. Because of the exposed nature of such surfaces, snow cover is thin or absent and abrasion by blowing snow may be severe. However, soil development beneath stable microsites may be relatively intense. The soils present are Pergelic (Lithic) Cryumbrepts if sufficient enmixed organic matter is present or Pergelic (Lithic) Cryochrepts if it is not (fig. B-11). Active layer thickness is greater than 1 m, and ice volumes beneath are generally low.

Solifluction forms, such as discontinuous stripes of frost scars or lobes, are common downslope from some outcrops and where slope breaks exceed 7 to 10

Figure B-9.--Elongate interfluve and slope pattern typical of the Rolling Coastal Plain terrain. Water tracks (horsetail drainage) are seen diverging from the crest and extending in a subparallel pattern toward a flowing stream. Water track soils are Pergelic or Histic Pergelic Cryaquepts. Those formed in the sedge tussock-frost scar slopes between the water tracks are Pergelic Cryaquolls and Pergelic Cryaquepts (fig. B-10). Photograph by K. R. Everett, Institute of Polar Studies, The Ohio State University.

Figure B-10.--Soil pedon common to Landsat cover category Vb (frost scar tundra). Soil to the right, a Pergelic Cryaquoll, consists of 5 cm of root mat and decomposed organic matter (1) overlying 18 cm of organic-rich loam/fine sandy loam with sporadic mottling (2). The lowermost 10 cm is gray, mottled fine sandy loam (3). Profile terminated at permafrost. Profile at left, a very poorly differentiated Pergelic Cryaquept, consists of 4 cm of light-grayish-brown fine sandy loam (1) overlying 10 cm of gray, mottled fine sandy loam with well-developed structure reflecting seasonal ice segregation (2). Bottom 20 cm consists of gray, mottled fine sandy loam. These profiles together form a pedon-Pergelic Ruptic-Entic Cryaquoll. Photograph by K. R. Everett, Institute of Polar Studies, The Ohio State University.

Figure B-11.--Foothills terrain type, Landsat cover category VII (moist dwarf shrub sedge tussock tundra complex). Birch tundra subunit VIIb occurs on raised-center polygons and polygon complexes (arrow 1). These forms are due to topographic reversal resulting from thermal erosion and thermokarst. Soils are Pergelic Cryosaprists or, in some cases, Pergelic Cryaquepts. Tussock tundra subunit VIIa with Pergelic Ruptic-Entic Cryaquolls is seen in upper right (arrow 2). The topography pictured there is common to headwater basins of many streams (fig. B-9). Photograph by K. R. Everett, Institute of Polar Studies, The Ohio State University.

percent. This is due principally to the water added from snowbank melt. Microrelief is relatively great, which, when combined with the high moisture environment, makes such areas highly susceptible to vehicular impacts.

The water track portion of the slope presents a relatively smooth and graded cross section. Polygonal outlines are usually not apparent, and the forms generally lack microrelief contrast. Ice wedges may still be extensive beneath such slopes. Soils are Pergelic Cryaquolls or Pergelic and Histic Pergelic Cryaquepts (the latter soil is not common). In most cases, 4 to 15 cm of Hemic or Sapric organic matter overlies mineral materials into which organic matter is commonly enmixed. Active layer thicknesses range between 30 and 50 cm. The presence of a water table is uncommon. Frost scar soils are composed of grayish-brown, usually mottled sandy textured mineral material. The lack of discernible profile development should dictate placement within the Entisols (possibly as Cryorthents); however, under the present system, the soil pedon is considered as Ruptic-Entic Cryaquoll. Active layer thickness ranges between 70 cm and greater than 1 m.

Histic Pergelic Cryaquepts are most common within the water tracks. Active layer thickness here is between 40 and 50 cm, and a water table is almost always present, commonly within 10 cm of the surface.

ALPINE TERRAIN TYPE

Alpine elements comprise only a small area of the portion of ANWR being considered here. The principal area of interest is at the northeastern end of the Sadlerochit Mountains. Crests here range narrowly around 1,250 m and have only sporadic vegetation and ground pattern. Soils consist of Pergelic Cryorthents (Cryochrepts may occur if textures are fine enough) interspersed with rock land (fig. B-12). Although permafrost is present beneath such surfaces, it is difficult to detect since the free drainage and exposed snow-free position precludes any significant accumulation of ice. However, experience elsewhere has shown (Everett, 1967) that ice may be present in some quantity in bedrock fractures.

Upper, steeper portions of most alpine slopes are mantled by scree or blocky talus (fig. B-13). These deposits commonly display block stripes and/or block-bordered terraces. It is common that ice fills the interstices of the finer cobble- and gravel-size fragments below the large surface blocks. Pockets of Pergelic Cryumbrepts, Cryochrepts, or, on occasion, Pergelic Cryaquolls do occur in finer textured materials (fig. B-14). Their presence and degree of development argue for the least local stability or very slow rock glacier movement on such slopes.

Below the talus, where vegetation cover is commonly complete and snowbanks develop, the slopes display a variety of solifluction forms including turf-banked terraces, lobes, and stripes. A complex of soils is found on such slopes that includes Pergelic or Histic Pergelic Cryaquepts in wet depressions, Pergelic Cryaquolls on somewhat better drained terrace or lobe fronts and occasionally Pergelic Cryohemists or Cryosaprists where slow deformation has produced folded and over-thickened organic horizons (fig. B-13). Active layer thickness on such slopes varies considerably, ranging to 70 cm or more in the wetter areas to less than 30 cm on some of the better drained microtopographic elements with organic-rich soils. Where coarse blocky talus underlies the solifluction slope, water movement in spring may cause piping and the distribution of mineral material over the surface of otherwise organic-rich soils. Solifluction slopes are naturally unstable with a complex of perched water tables and subsurface drainage and are

Figure B-12.--Alpine area (Sadlerochit Mountains). Areas with bedrock at or very close to the surface may lack vegetation and soils. Commonly, however, there is a complex of Cryochrepts (Cryumbrepts), Cryorthents, and nonsoil. Sorted and nonsorted stone nets are also common. Solifluction slopes occur below talus slopes (arrow 1) and have a variety of soils, including Pergelic Cryaquepts, Histic Pergelic Cryaquepts, Pergelic Cryorthents, Pergelic Cryochrepts or Cryumbrepts (fig. B-14) and rarely Pergelic Cryosaprists. Sedge tussock-frost scar tundra occurs on the more gentle slopes (arrow 2). Photograph by K. R. Everett, Institute of Polar Studies, The Ohio State University.

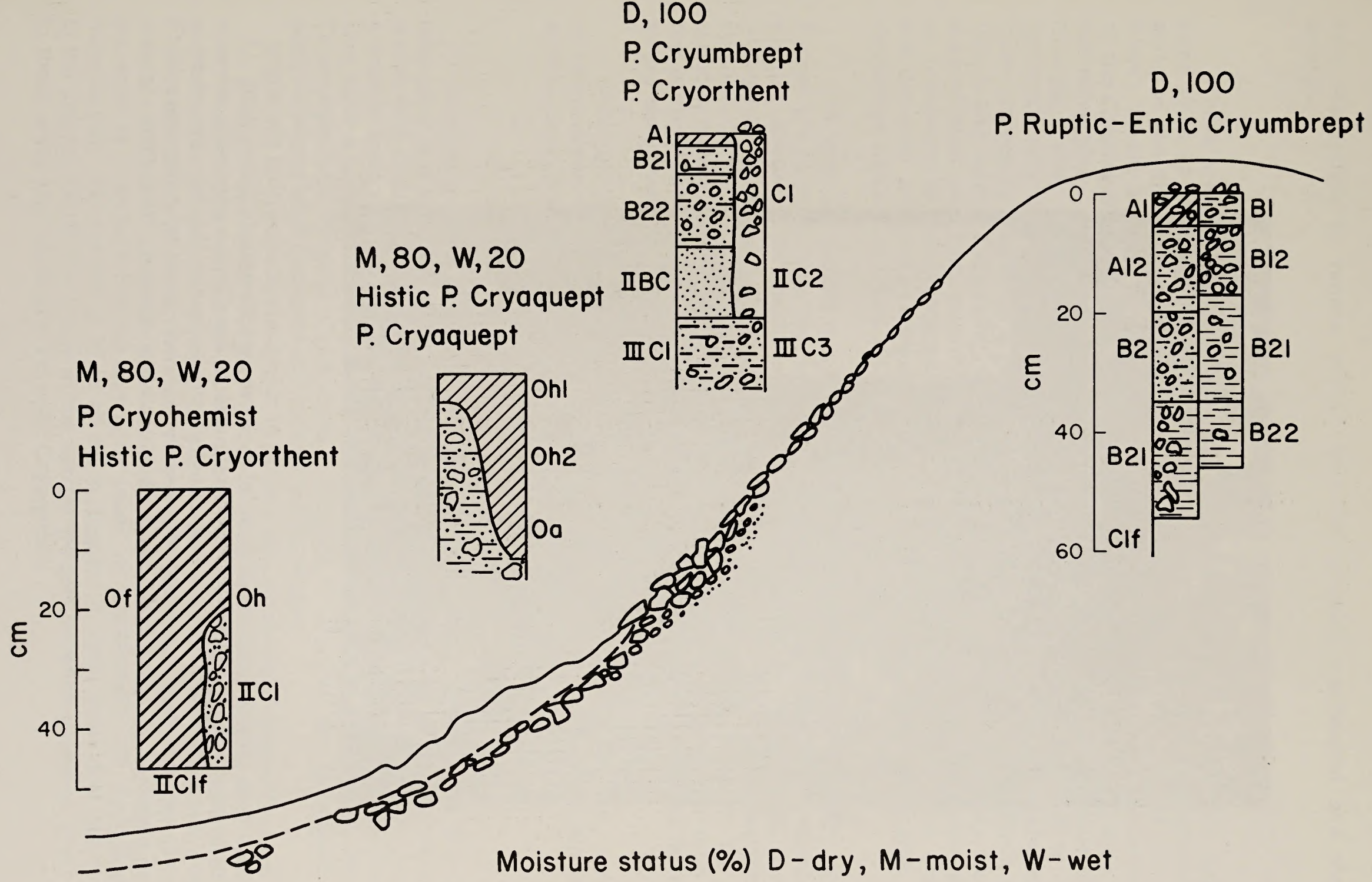


Figure B-13.—Idealized Toposequence Across Alpine Terrain Type, Arctic National Wildlife Refuge

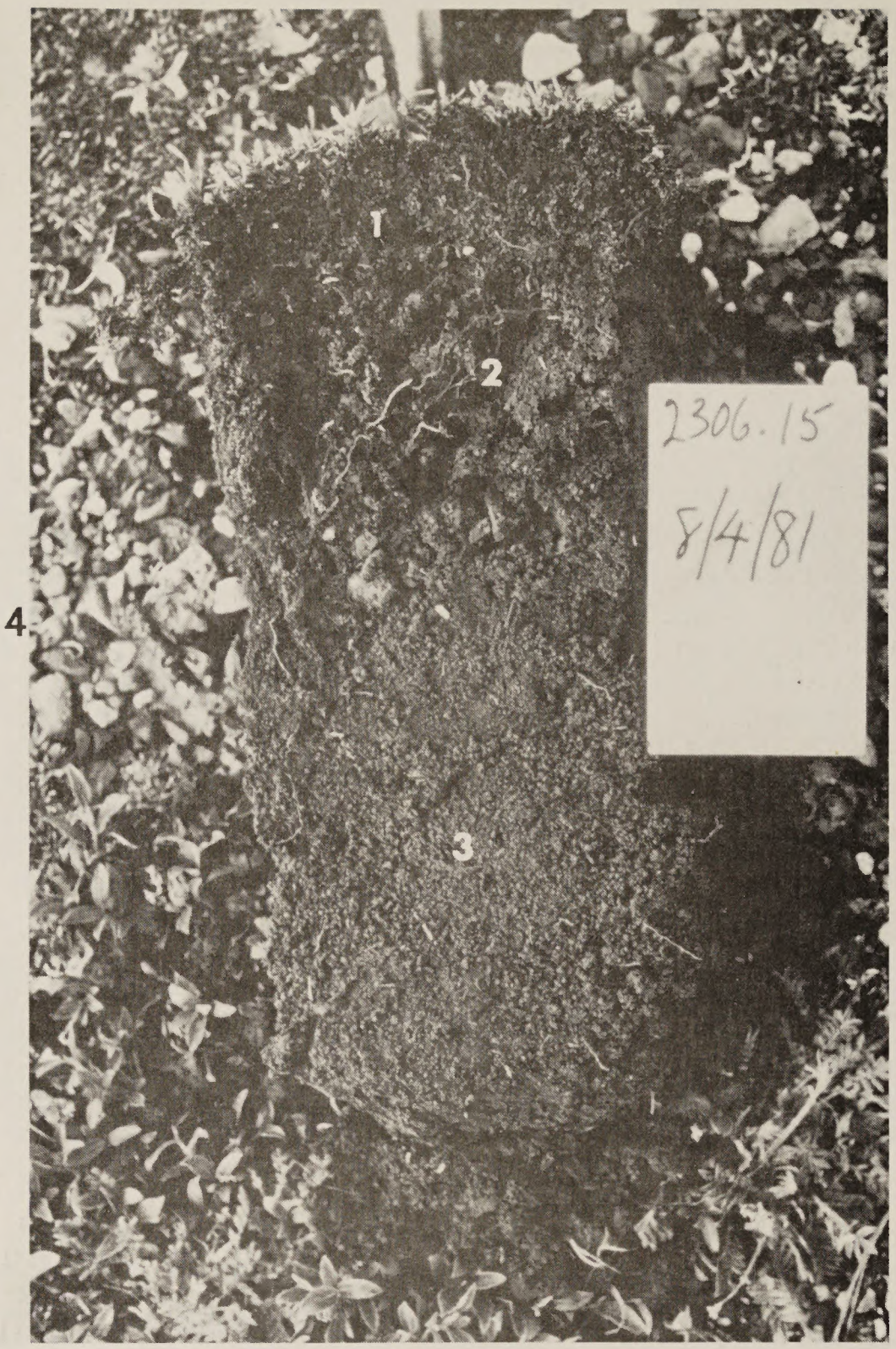


Figure B-14.--Pergelic Cryumbrept soil typical of the stable areas within the alpine region. This profile consists of 5 cm of turfy organic matter (1) overlying 13 cm of gravelly fine sandy loam (2). The lower 18 cm (3) is a generally stone-free fine sandy loam with well-developed subangular blocky structure. Commonly, the turfy A horizon is absent or is interrupted by frost scars (4). Photograph by K. R. Everett, Institute of Polar Studies, The Ohio State University.

very susceptible to vehicle traffic that can produce mechanical and thermal erosion.

FLAT THAW-LAKE PLAINS TERRAIN TYPE

These areas are best developed in the delta of the Canning River and for some 12 to 15 km eastward in a narrow coastal belt and a narrow zone between the delta of the Hulahula River and a point some few kilometers east of the Jago River. Barter Island is included in this zone. With the exception of the delta area of the Canning River, the thaw-lake plains appear to be remnants of a once more extensive plain. They are topographically similar to the lake plain east of the Canning River, being composed of up to 30 percent water confined to small (generally less than 260 ha), shallow, eliptical oriented lakes. Areas between the lakes are poorly drained as a result of very low surface hydraulic gradient and a thin active layer. Except for the vegetation-covered basins of relatively recently drained lakes some form of microrelief is nearly always present. It consists mostly of low-centered non-orthogonal polygons, strangmoor, or complexes of disjunct low-centered polygons, strangmoor, and featureless areas associated with pond complexes (table B-1; fig. B-15).

The area is underlain by ice-rich permafrost at depths of about 40 cm. Except for polygon rims, the perched water table is very close to the surface or slightly above it for most or all of the thaw period. Fibrohistic Pergelic Cryaquepts or occasionally Histic Pergelic Cryaquolls and Pergelic Cryaquepts are common to the wet and very wet areas. Pergelic Cryaquolls occur on the more mesic polygon rims. The soils are all neutral to slightly alkaline in reaction, even the saline Fibrohistic Pergelic Cryaquepts and Cryohemists inundated by storm surges along some coastal areas (fig. B-16).

Vehicular impact (single pass) on coastal plain soils is almost totally confined to compression of the organic surface horizons and in some cases tearing of the surface organic horizons.

ROLLING COASTAL PLAIN TERRAIN TYPE

Stretching inland between the Hulahula and Jago Rivers from the flat thaw-lake plain is a complex region of very gently undulating tussock tundra, thaw-lake plains, and pond complexes (HCP in fig. III-3). Elevations within the region rise gradually from near 30 meters to about 100 meters. The lowland portions of this area have a surface with 50 percent wet graminoid tundra and Fibrohistic Pergelic Cryaquepts and Pergelic Cryaquepts. Pergelic Cryaquolls are associated with positive microrelief elements and tussock tundra slopes.

The gently sloping (5 percent or less) interfluves have mostly moist (greater than 75 percent) tussock tundra with flat-centered polygons. Frost scars occupy greater than 30 percent of most surfaces and are considered to have Pergelic Cryaquept soils with loam and fine sandy loam textures. Soils between the frost soils are Pergelic Cryaquolls and commonly have from 8 to 12 cm of Sapric organic material as a surface horizon overlying loam, or occasionally silt loam-textured mineral soil. Permafrost is 35 to 45 cm in August. A water table does not develop in the polygon centers but may in the narrow troughs between polygons where soils in these areas are Fibrohistic Pergelic Cryaquepts.

Figure B-15.--Histic Pergelic Cryaquept soil typical of the Thaw-Lake Plain terrain and Landsat cover category III (wet sedge tundra). Here, approximately 38 cm of fibrous organic material overlies gray, weakly mottled silt loam (arrow 1). In cases where the organic materials exceed 40 cm, the soil is designated a Pergelic Cryofibrist. Which of the two soils occurs at a given site is usually not possible to tell. These soils may be associated with Pergelic Cryaquolls and/or Pergelic Cryaquepts that occur on slightly higher microrelief elements; e.g., polygon rims. Photograph by K. R. Everett, Institute of Polar Studies, The Ohio State University.

Figure B-16.--Coastal area subject to marine inundation during storm surges. Note driftwood. Soils of such areas are best described as Halic Pergelic Cryaquepts and/or Halic Histic Pergelic Cryaquepts. Photograph by K. R. Everett, Institute of Polar Studies, The Ohio State University.

The tussock slope components are quite susceptible to vehicular traffic associated with seismic traverses which commonly results in crushing or abraiding of the tussocks. (See Reynolds, 1981.)

BEACHES, SPITS, AND BARS

Such features occupy a very small percentage of the study area. Soil development is either lacking or in some stable sites Cryorthents are recognized. Permafrost, although it probably underlies these sites, does not enter into the soil taxonomy. Vehicular impact in these areas may be severe, producing ruts. Such features are, however, usually transitory, being obliterated by storms.

SAND DUNES

Sand dunes are rare in ANWR and are confined mostly to the delta areas of the Canning and Jago Rivers. The features are small, mostly less than 1.5 m high and composed of fime sand with a significant silt component. The soils are Pergelic Cryopsamments. Small sand dunes are highly susceptible to vehicular traffic and may undergo extensive reshaping and erosion as a result of it.

GENERAL CHARACTERISTICS AND TAXONOMY OF PRINCIPAL SOILS WITHIN THE ARCTIC NATIONAL WILDLIFE REFUGE

The term "soil," as used in this report, refers to the thawed layer of ground observed in August. The nomenclature is that of the U.S. Department of Agriculture, Soil Conservation Service Manual 430, 1981 Draft and Handbook 436 (Soil Survey Staff, 1975), unless otherwise noted in the text.

Of the 10 soil orders recognized in this soil taxonomy, 4 are found in ANWR. (See table B-1.) Soils belonging to the order Mollisols are probably the most extensive. They occur in all terrain types, particularly in the foothills and the hilly coastal plain. Mollisols are dark-colored mineral soils. The dark color is a reflection of at least 2.5 percent organic carbon in the upper 18 cm of the profile. In addition to the dark color, Mollisols have a base saturation greater than 50 percent--that is, Mollisols are neutral or slightly alkaline in reaction (pH).

Wet Mollisols are classified as Aquolls (aqu indicating an aquic (reducing) moisture regime and oll indicating the soil order Mollisols). The prefix Cry appears at the Great Group level of classification for all soils found in ANWR and indicates a mean annual temperature of less than 8°C. The term "Pergelic" (permanently frozon appears at the subgroup level of all ANWR soils. Thus, Pergelic Cryaquoll defines a cold, wet, dark-colored, base- and organic-rich mineral soil underlain by permanently frozen material. Pergelic Cryaquolls occurring in very wet areas may have a surface horizon with 20 to 40 cm of organic material. These soils are designated as Histic Pergelic Cryaquolls (the term "Histic" indicates an organic surface horizon greater than 20 cm thick). Mollisols on well-drained sites are termed "Pergelic Cryoborolls."

The next most extensive soil order represented in ANWR is the Inceptisols. These are mineral soils that have only weakly differentiated soil horizons, primarily due to the ineffectiveness of the leaching process in the cold, wet tundra. Organic carbon in the Inceptisols is not evenly distributed in a distinct mollic epipedon (dark-colored, base-rich surface horizon) as in the Mollisols.

Aquepts are wet Inceptisols that commonly show some degree of mottling (iron oxidation) in the mineral soil below the organic surface horizon. The mineral soils generally are gray, reflecting a saturated, reducing environment. In some cases an organic surface horizon greater than 20 cm thick forms the epipedon (surface horizon), and these soils are termed "Histic Pergelic Cryaquepts." Most Cryaquepts show some quantity of organic matter mixed in the subsurface horizons, presumably concentrating at or near the seasonal permafrost table. Many Cryaquepts developed in silt, silt loam, or fine sandy loam display thixotropic characteristics and will flow spontaneously upon vibration.

Cryaquepts are common components of soil complexes and are often associated with Mollisols, particularly where they occur with frost scars. In such cases, the complex is termed "Ruptic- (interrupted) Cryaqueptic Cryaquoll." The term "Entic" (Entisol) may replace Cryaqueptic if frost-scar soils show little or no horizon development.

Relatively well drained and stable sites, especially on ridge crests, have Pergelic Cryumbrepts, which are Inceptisols with an umbric (dark colored due to

organic matter) surface horizon underlain by an acid (base-poor) subhorizon. Similar soils lacking the umbric surface horizon are usually designated Cryochrepts.

Perhaps the least extensive and least predictable in occurrence are the organic soils (Histosols). These soils have a surface horizon composed of greater than 40 cm of organic materials and generally greater than 60 percent organic matter overlying gray, sometimes mottled, fine-textured mineral materials. Normally, these soils are very wet, to the extent that the organic materials are buoyant or partially so. They occur on flat areas, either on ridge crests or in lowlands. Three taxa of cold Histosols are recognized: Pergelic Cryofibrists (fibrous, low-density organic matter), Pergelic Cryosaprists (non-fibrous, highly decomposed and dense organic matter), and Pergelic Cryohemists (with intermediate organic matter characteristics). Histosols may have any pH, although in ANWR most are nearly neutral in reaction.

Entisols are soils with little or no horizon development. They are common on unstable sites such as sand dunes, flood plains, and talus areas. Cryopsamments are sandy Entisols that are subject to blowing and drifting. Cryorthents are more coarse and are composed of gravels, rocks, and such materials as are found in recent mudflows, glacial deposits, and stabilized river alluvium.

LANDSAT-ASSISTED ENVIRONMENTAL MAPPING IN THE ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA

By D. A. Walker, K. R. Everett, W. Acevedo,
L. Gaydos, J. Brown, and P. J. Webber

NOTE: Several of the table and figure references in this report are now coded to refer to items used within the EIS or within the Soils report of this appendix.

Prepared for
U.S. Geological Survey
U.S. Fish and Wildlife Service

United States Army
Corps of Engineers
Cold Regions Research and Engineering Laboratory
Hanover, New Hampshire, U.S.A.

PREFACE

This report was prepared as input to the environmental impact statement required under Section 1002 of the Alaska National Land Conservation Act (ANILCA) of 1980. The experience gained with Landsat and geobotanical mapping in other parts of northern Alaska over the past 8 years was applied to this large and relatively unknown region of northeastern Alaska. Much of the experience required to accomplish the project was gained through studies supported by the Department of Energy, the U.S. Geological Survey (USGS), and the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL). This specific study was supported by the USGS and the U.S. Fish and Wildlife Service (USFWS).

This report was prepared by Dr. Donald A. Walker, Research Associate, INSTAAR, University of Colorado; Dr. K. R. Everett, Professor, Institute of Polar Studies, Ohio State University; William Acevedo, Senior Data Analyst, Technicolor Government Services, USGS, NASA/Ames Research Center; Leonard Gaydos, Chief, Geographic Investigations Office, USGS, NASA/Ames Research Center; Dr. Jerry Brown, Chief, Earth Sciences Branch, Research Division, CRREL; and Dr. Patrick J. Webber, Professor and Director of INSTAAR, University of Colorado.

James R. Wray, USGS, Reston, Virginia, was responsible for the design of the Landsat landcover map. Carol Hurr, Office of Surface Mining Reclamation and Enforcement, Denver, Colorado, and Dr. John Haugh, Minerals Management Service, Reston, Virginia, provided editorial and technicai assistance in compiling early portions of the report.

The USFWS (Anchorage, Alaska), under Dr. William Kirk's direction, organized the logistics in August 1981 to accomplish the initial field ground check. Bob Bartles of the USFWS Barter Island field station and personnel of the DEW (Distant Early Warning) line site provided considerable assistance for the fieldwork.

The report was reviewed by Dr. Vera Komarkova, Research Associate, INSTAAR; Dr. Paula Krebs, Bureau of Land Management, Anchorage; Paul Brooks, Chief, USGS Alaska Program Office; Mark Shasby, Technicolor Government Services, Alaska Operation, Anchorage; Carolyn Merry, CRREL; and Carol Simmons, University of Colorado. John Hall of the USFWS and Karen Howe of CRREL reviewed the NWI equivalents in table B-6. The comments of the reviewers are greatly appreciated; they provided the basis for numerous changes in the original manuscript, parts of which are included in the Environmental Impact Statement and Baseline Studies for the Arctic National Wildlife Refuge.

The contents of the report are not to be used for advertising or promotional purposes. Citation of brand names does not constitute an offical endorsement or approval of the use of such commercial products.

LANDSAT-ASSISTED ENVIRONMENTAL MAPPING IN THE ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA

ABSTRACT

This report presents a Landsat-derived landcover map of the northwest portion of the Arctic National Wildlife Refuge, Alaska. The report is divided into two parts. The first is devoted to the landcover map with detailed descriptions of the mapping methods and legend. The second part is a description of the study area. The classification system used for the maps is described in detail. It is a comprehensive method of nomenclature for large- and small-scale mapping of tundra vegetation, suitable for describing vegetation complexes, that are common in the patterned-ground terrain of the Alaskan Arctic. The system is applicable to Landsat-derived landcover classifications. The description of the study area focuses on five primary terrain types: flat thaw-lake plains, hilly coastal plains, foothills, mountainous terrain, and river flood plains. Topography, landforms, soils, and vegetation are described for each terrain type. The report also contains area summaries for the Landsat-derived map categories. The area summaries are generated for the five terrain types and also the 89 townships within the study area. The report contains figures, mainly photographs, of the terrain and landcover types, tables, and detailed descriptions of the landcover units and the soils. Two colored maps (plates 1 and 2 of the EIS) are included -- the USGS-published map of the Landsat-derived landcover classification and a hand-drawn simplified landcover map suitable for very small scale mapping programs.

SUMMARY

This report describes the landforms, soils, and vegetation in a 1.4-million-acre (5,700-km^2) portion of the Arctic National Wildlife Refuge (ANWR) in Alaska. The area is being considered for seismic oil exploration activities scheduled to begin in December 1982. A 1:250,000 colored Landsat landcover map of the study area was derived from Landsat data as part of this project and was used extensively in the terrain analysis. Descriptions of the environment are based on a 7-day reconnaissance trip in August 1981 that concentrated in four townships of the study area. The field data are supplemented with information from 1:60,000-scale, color-infrared (CIR) and 1:18,000-scale, color aerial photographs. The report is divided into two parts. The first describes the Landsat map, the methods for making it, and the legend. The second is a description of the ANWR study area based on the major terrain types.

The Landsat-derived landcover map consists of a digital mosaic of portions of three Landsat scenes. The landcover classification consists of the following map categories: (I) Water; (II) Pond Complex or Aquatic Tundra; (III) Wet Sedge Tundra; (IV) Moist/Wet Sedge Tundra Complex or Dry Prostrate Shrub, Forb Tundra; (V) Moist Sedge, Prostrate Shrub Tundra or Moist Tussock Sedge/Barren Tundra Complex (frost scar complex; (VI) Moist Tussock Sedge, Dwarf Shrub Tundra; (VII) Moist Dwarf Shrub Tundra Complex (water-track complex); (VIII) Shrub Tundra; (IX) Partially Vegetated Areas; (X) Light-colored barren gravel or rock; (XI) Darker colored gravel or barren mud; and (XII) Ice. The landcover classification system is briefly explained and equivalent units are given for six other vegetation, wetland, and landcover classification systems.

The study area is divided into five terrain types. These types delineate relatively large areas with similar primary landforms. They are, with their percentage of the study area in parentheses: Foothills (44.7 percent), river flood plains (24.6 percent), hilly coastal plains (22.4 percent), ocean (5.2 percent), flat thaw-lake plains (3.1 percent), and mountainous (alpine) terrain (0.03 percent).

Foothills are the most common terrain type in the study area. Tundra with sedge tussocks and dwarf shrubs covers most foothill uplands. Dominant plants include sheathed cottongrass (Eriophorum vaginatum), numerous ericaceous shrubs, dwarf birch (Betula nana), and diamond-leafed willow (Salix planifolia ssp. pulchra). Shrub cover varies in upland tundra types and is responsible for much of the variation in spectral reflectances from moist tundra vegetation. Water tracks, stream valleys, and south-facing slopes are likely to have well-developed shrub communities. Frost scars occur on most upland surfaces and may cover up to 90 percent of the surface. Most soils are Pergelic Cryaquolls or Pergelic Cryaquepts, although Histic Pergelic Cryaquepts are the most common soils in water tracks.

River flood plains are highly complex landscapes that include the present flood plains as well as former braided drainages and river deltas. These areas cover large portions of the study area and include such features as bluffs, terraces, wet tundra, gravel bars, dunes, mud flats, and river icings. Willow communities are common along the rivers.

Hilly coastal plains occur north of the foothills, particularly east of the Hulahula River. The vegetation and soils are a combination of those found in the foothills and those found in the flat thaw-lake plains. Wet sedge tundra covers about 23 percent of the unit, and complexes of moist and wet sedge tundra cover about 34 percent. Upland tundra types cover about 40 percent of the unit. Wet tundra areas are mostly confined to depressions between low ridges that have an east-west orientation. Flat hillcrests often have extensive thermokarst pits.

Flat thaw-lake plains are restricted to small areas near the coast and are dominated by wet sedge tundra and complexes of moist and wet sedge tundra. Large portions of these areas are covered by lacustrine complexes. The vegetation and soils are strongly controlled by microrelief associated with patterned ground, mainly ice-wedge polygons and strangmoor. The dominant plants are water sedge (Carex aquatilis), other sedges, and mosses. The dominant soils are Pergelic Cryaquepts and Histic Pergelic Cryaquepts, with thick, fibrous, organic surface horizons. In wetter areas these soils often form complexes with true organic soils, mainly Pergelic Cryohemists. Moderately well drained areas often have mineral soils, Pergelic Cryaquolls, usually associated with frost boils. The vegetation near the coast is affected by a steep summer temperature gradient. Beaches, lagoons, estuaries, and low-lying areas, which are all inundated by sea water during occasional storm surges, support saline-tolerant plant communities and saline soils.

Mountainous terrain occurs only in a small corner of the study area, near Sadlerochit Spring. Surface forms consist of blockfields, talus slopes, sorted stone nets, steep solifluction slopes, and rock outcrops. Soils are restricted to small areas where finer materials can collect. Pergelic Cryorthents form complexes with rockland, Pergelic Cryochrepts, Pergelic Cryaquepts, and, occasionally, Cryohemists in solifluction areas. The landcover in most alpine areas is classed as either Barren or Partially Vegetated, due to the abundance of rock, but fairly lush tundra vegetation occurs locally on partially stable terrain.

A summary table (table III-2) describes each terrain type in terms of the dominant Landsat-based landcover units, landforms, soils, and vegetation communities.

INTRODUCTION

The Alaska National Interest Lands Conservation Act (ANILCA) of 1980 created the present boundaries of the Arctic National Wildlife Refuge (ANWR). Under this legislation, 1.4 million acres (5,700 km^2) of the northern portion of the refuge (fig. III-1) was opened to oil and gas exploration at the discretion of the Secretary of the Interior. The area, henceforth referred to as the ANWR study area, is being considered for seismic oil exploration that is scheduled to begin in December 1982.

Before exploration can begin, an environmental impact statement (EIS) must be prepared to satisfy Section 1002(d) of ANILCA. A baseline study was prepared under Section 1002(c) of ANILCA to serve as the basis for the EIS and for regulating future exploration. The extent, location, and carrying capacity of wildlife habitats are major emphases of the baseline studies, and vegetation maps are required for examining wildlife habitats. Because existing vegetation maps covering the study area were too general for habitat studies, a new 1:250,000-scale landcover map was required, and Landsat-assisted mapping was deemed the most practical approach. A Landsat-based landcover map (plate 1) was produced between August 1981 and April 1982.

This report is divided into two parts. Part I is devoted to the landcover map, with discussions of the mapping methods and legend. The legend is a step toward a Landsat classification system for tundra. Part II consists of general descriptions of the major terrain types within the ANWR study area.

Part I

A LANDCOVER MAP OF THE ANWR STUDY AREA

There are two main objectives for this mapping project:

1. To produce a landcover map of the ANWR study area that has wide application for wildlife and land use studies.

2. To develop a legend that is appropriate for Landsat and that has application to other areas in northern Alaska.

A Landsat-derived landcover classification was deemed the most suitable approach for this mapping project for several reasons:

1. The map had to be prepared in less than 1 year; Landsat-assisted mapping is the quickest method for mapping large areas.

2. The area is large and generally inaccessible for detailed mapping on the ground.

3. Funds were insufficient for conventional mapping by interpretation of aerial photographs, and not all of the area was covered on aerial photographs.

4. Landsat provides digital, geographically referenced information that lends itself well to geographic-based information systems. Other data bases can be registered to it, and various analyses, such as area measurements, can be performed easily, Also, maps can be converted to different scales or th boundaries changed.

Our recent work in the Prudhoe Bay region (Walker and Acevedo, in preparation) has shown that excellent Landsat-derived landcover maps can be prepared for the tundra of the Arctic coastal plain. The coastal plain has two attributes that aid in interpreting Landsat data. First, the terrain is flat or gently rolling, so deep shadows do not create problems in interpretation, as they do in mountainous areas. Second, the vegetation is all low growing; there are no trees to mask the terrain or other vegetation.

LEGEND DEVELOPMENT

Criteria for Landsat-Derived Tundra Legends

Although Landsat-derived maps have been developed for several areas of northern Alaska (Belon and others, 1975; Nodler and LaPerriere, 1977; Nodler and others, 1978, Lyon and George, 1979; Morrissey and Ennis, 1981), there has not yet been an attempt to develop a comprehensive Landsat landcover legend applicable to all areas of the Alaskan arctic tundra. There are, however, numerous classification systems that were examined for potential application to this mapping objective. These fit in three categories: Remote-sensor landcover classifications (Anderson and others, 1976; Nodler and La Perriere, 1977), wetland classifications (Cowardin and others, 1979; Bergman and others, 1977), and vegetation classifications (Fosberg, 1970; UNESCO, 1973; Driscoll and others, 1981; Viereck and Dyrness, 1980). A full discussion of the merits of, and problems with, each system is beyond the scope of this report; none satisfied the objective of this project. A satisfactory legend for Landsat-assisted mapping of tundra vegetation must meet several criteria.

First, the legend must be based on the characteristics of tundra vegetation that can be recognized on Landsat imagery. Our experience with Landsat imagery and tundra (Walker and Acevedo, in preparation) has shown that there are two primary aspects of Arctic Alaskan coastal tundra vegetation that affect its spectral reflectance--the amount of water on the surface and the percentage of shrubs in the vegetation canopy. Numerous secondary factors, such as the openness of the graminoid layer, the color of the substrate, the amount of erect, dead graminoid vegetation, and the nutrient status of the site, also affect the reflectance. A classification system for Landsat-based mapping should recognize the effect of moisture and shrub cover on spectral reflectance. The secondary factors are more difficult to classify consistently, but they should be considered during photointerpretation.

Second, a classification system should be flexible enough to describe the great variety of tundra communities. There has not yet been sufficient experience with Landsat imagery of tundra environments to establish a final set of units with which to categorize all tundra landscapes. Most approaches have attempted to force Landsat interpretations into rather rigid legend systems that have never been applied to detailed tundra mapping or that simply are not suitable for a Landsat approach.

Third, a classification system should use consistent criteria in naming vegetation units. This is emphasized in all major national and international mapping systems. Most of these systems recognize the importance of diminant plant growth forms. We have found that a combination of the dominant plant growth forms and site moisture can be used consistently for maps of tundra vegetation. The system should also have a consistent method of describing vegetation complexes (i.e., areas where there are mixtures of vegetation communities) that are particularly common in the patterned-ground landscapes of the Arctic.

Finally, the small-scale Landsat-based legend units should be able to serve as a basis for more detailed, community-level mapping without changing the system. It is also important that the system should be cross-referenced to the other classification systems currently in use in Alaska.

The classification system developed here satisfies these criteria. The map itself is a major step toward producing accurate vegetation maps for the entire Arctic Slope of Alaska. The classification system used here is based on a method of describing plant communities that was developed at Prudhoe Bay, Alaska (Walker and others, 1980; Walker, 1981). This nomenclature system is first explained for large-scale maps so that the basis of the smaller scale Landsat-level map units can be better understood.

Nomenclature for Large-Scale Vegetation Mapping

Community nomenclature for large-scale mapping (1:12,000 scale or larger) incorporates four major parts: (1) a site moisture term, (2) the dominant plant species in each part of the vegetation canopy, (3) the dominant plant growth forms, and (4) an overall physiographic descriptor. These parts are always arranged in this sequence.

The site moisture term can be DRY, MOIST, WET, or, if the vegetated area is permanently covered with deep water, AQUATIC. The site moisture term is followed by the names of the dominant plant taxa, usually one or more from each of the shrub, herb, and cryptogam components of the vegetation. The number of taxa is kept to the minimum required to adequately distinguish the community from others on the map, the total never exceeds six.

The terms used for plant-growth forms are: (1) tall shrubs (greater than or equal to 2 m tall), (2) medium shrubs (0.5 to 2 m), (3) dwarf shrubs (0.1 to 0.5 m), (4) prostrate shrubs (less than 0.1 m), (5) tussock graminoids, (6) nontussock graminoids, (7) forbs, (8) mosses, and (9) lichens. All low-growing (less than 0.1 m high) woody plants, such as Dryas integrifolia and Arctostaphylos rubra, are classed as prostrate shrubs. The graminoid vegetation is further broken down into either sedge- or grass-dominated units. Cushion plants, such as Saxifraga oppositifolia and Oxytropis nigrescens, are included in the forb category. Lichen vegetation is further broken down into crustose- or fruticose/foliose-lichen-dominated units. If a vegetation unit is dominated by more than one growth form, each covering at least 30 percent of the ground, it will have more than one growth form in its name (e.g., MOIST TUSSOCK SEDGE, DWARF SHRUB TUNDRA).

The physiognomic descriptor TUNDRA is used for all arctic and alpine nonforested areas with generally continuous ground cover, The physiognomic term BARREN is applied to units with less than 30 percent vegetation cover. The site

moisture term, the dominant plant growth forms, and the physiognomic descriptor have all uppercase letters, and the plant names are italicized.

An example of a community name using this system is WET Carex aquatilis, Drepanocladus brevifolius SEDGE TUNDRA. A more complex example with two dominant growth forms is MOIST Eriophorum triste, Dryas integrifolia, Salix arctica, Tomenthypnum nitens, Thamnolia subuliformis SEDGE, PROSTRATE SHRUB TUNDRA.

Vegetation complexes are also described with a uniform nomenclature. A unit is considered a complex if it contains two or more distinct communities, and each community covers at least 30 percent of the area. In the Arctic, community mosaics occur mainly as a response to minor elevation differences associated with ice-wedge polygons, frost boils, water tracks, strangmoor, solifluction lobes, and other kinds of patterned ground. Most of the individual communities are too small to map even at the 1:6,000 scale. In this nomenclature, the term COMPLEX is attached to the end of the landcover name, and the major elements of the complex are separated by a slash (/).

For example, a map unit composed of wet sedge tundra and moist sedge tundra is called a WET/MOIST SEDGE TUNDRA COMPLEX. The most abundant unit of the complex is named first. A map unit with a wet, dwarf-shrub community occurring in the water tracks of tussock-sedge, dwarf-shrub tundra would be named MOIST TUSSOCK SEDGE, DWARF SHRUB/WET DWARF SHRUB TUNDRA COMPLEX.

At large scales, complexes of vegetation can be described by the nature of the surface form on which the complex occurs. For example, vegetation on a foothill area with water tracks would have the following explanation in the legend: MOIST TUSSOCK SEDGE, DWARF SHRUB/WET DWARF SHRUB TUNDRA COMPLEX (water-track complex):

(a) Interfluves and upland tundra areas: MOIST Eriophorum vaginatum, Betula nana, Salix planifolia, Ledum decumbens, Sphagnum sp., Cladina sp. TUSSOCK SEDGE, DWARF SHRUB TUNDRA
(b) Water tracks: WET Salix planifolia, Betula nana, Carex aquatilis, Sphagnum sp. DWARF SHRUB TUNDRA

The term "water-track complex" could be used as a shorter synonym in general discussion.

Nomenclature for Small-Scale Vegetation Mapping

For small-scale Landsat-level mapping, the details of community composition can rarely be included, but the site moisture term, the dominant plant growth forms, and the physiognomic descriptor can normally be retained in the landcover titles. There are, however, numerous exceptions. With Landsat, it is sometimes difficult to separate rather distinct landcover types solely on the basis of spectral reflectance, and it may be necessary to describe a map category (i.e., one color on the map) with several landcover types. For example, "Pond/Sedge Tundra Complex, or Aquatic Graminoid Tundra, or Shallow Water" describes a map category consisting of several very wet landcover types that could not be distinctly separated in the Landsat data.

Sometimes it may also be necessary to drop part of the landcover title. For example, it may not be possible to distinguish Wet Medium Shrub Tundra from Wet Dwarf Shrub Tundra or Dry Medium Shrub Tundra, so the term Shrub Tundra could be used. Every attempt should be made to retain the complete title, since this increases the amount of information available on the map. However, in some cases, the vegetation within a map category may vary so widely that it is not possible to use the nomenclature system at all. Partially vegetated areas are often of this nature.

At small scales, the system is not rigid. It simply offers a means of describing tundra landcover as consistently as possible. The system for mapping at small scales is strongly rooted in the nomenclature system for large-scale mapping, in that there is a natural nesting of nomenclature at four levels (table B-6).

MAPPING METHODS

The mapping methods consisted of (1) acquiring ground reference data from aerial photographs and field data, (2) preparing the landcover classification from the digital Landsat data, and (3) composing and printing the final colored map. Computer-generated data provided detailed area summaries for each map category (plate 1). In addition, a simplified hand-drawn landcover map with polygonal map category boundaries was prepared for smaller scale mapping programs (plate 2).

Ground Reference Data

Ground reference data for the project were gathered during a USFWS-supported helicopter survey, August 12-17, 1981. The survey was concentrated in four townships (table B-5) that included the major landform features within the ANWR study area. This information was supplemented with extensive ground reference data gathered from similar Alaskan arctic areas outside ANWR during the past several years.

The field method consisted of locating large, homogeneous areas of terrain on 1:60,000-scale aerial color-infrared (CIR) photographs and then describing (from the air) the vegetation (e.g., wet sedge tundra; dwarf shrub, tussock sedge tundra; partially vegetated), and the landforms (e.g., low-centered polygon strangmoor; water tracks). In particularly homogeneous areas or areas that appeared to be representative of common units, we took detailed notes for the vegetation, site factors, and soils. Vegetation complexes were described if they were extensive and were associated with distinctive patterned-ground features. Each area was photographed from the air and on the ground.

We spent most of the field time describing map units from the air. This could be done readily, since most of the vegetation and soils are similar to those we have encountered in other areas of northern Alaska. This method allowed us to cover as much terrain as possible with the limited amount of helicopter support. We took detailed notes regarding species composition in 35 stands of vegetation. We hoped that these data will be supplemented with additional quantitative information in future years and will be presented in a separate report.

Computer Classification of the Landsat Data

The methods employed for producing the landcover classification from the Landsat data were those available at the USGS Geographic Investigations Office at

Ames Research Center, Moffett Field, California (Morrissey and Ennis, 1981). Three Landsat scenes were selected for analysis. The eastern two-thirds of the study area were covered by scene 22008-20420 (22 July 1980) acquired from the Canada Center for Remote Sensing. The remainder of the region was covered by scene 21633-20531 (13 July 1979), except for a small wedge in the southwest corner, which was covered by scene 25070-20462 (14 August 1976). Each scene had to be treated separately in the analysis process to account for the variation in spectral response among scenes and because of phenological changes in vegetation from year to year. The manipulated results were later merged to create a landcover map for the study area.

A clustering algorithm was used to define discrete classes of pixels on the basis of their reflectance in the four Landsat spectral bands. The analyst selected the number of classes on the basis of previous experience with similar Landsat data and on an estimate of the desired number of classes in the final classification. The numbers of clusters designated for this study were 28 for scene 25070-20462, 35 for scene 21633-20531, and 31 for scene 22008-20420. A systematic 10 percent sample of the pixels from each Landsat scene was used in the clustering algorithm. This algorithm sorts the Landsat data into classes such that the pixels within each class are as similar to each other as possible and the pixels from different classes are as different from each other as possible. These clusters describe in statistical terms (means and covariances) the spectral properties of Landsat data (Swain, 1972).

It was expected that these clusters would describe only general landcover units and not the specific unit desired. Therefore, the ground reference data were used to full advantage. Landsat pixels from each of four ground reference areas were clustered separately. The resulting clusters were used to define vegetation classes, while the 10 percent sample was used to select clusters representative of ice, water, and barren land.

At this point, some vegetation classes were still not well defined by clusters. These were classes that occurred rarely in the areas studied. It was likely that there were not enough pixels containing these vegetation types to allow them to be segregated into distinct clusters; hence, they were initially included in spectrally similar clusters. To handle these special cases, known occurrences were defined and mapped from the ground reference information. Pixels from these locations were then clustered independently, without consideration of other classes in the area, to produce sharper spectral classes.

Thus, a final set of clusters, as defined by spectral statistics, was produced for each scene. Each pixel in the scene was assigned to a cluster, using discriminant function analysis to determine the cluster to which the pixel had the greatest probability of belonging (Gaydos and Newland, 1978).

By viewing the results on a color-image display, the analyst was able to enlarge small portions of the Landsat scene. He could also view only the pixels in a selected spectral class by assigning a color to that class. He then identified the vegetation in the spectral class based on field notes ahd high-resolution color-infrared photography. This most important interpretation step was aided immensely by field experience.

Each cluster was interpreted and assigned to a map category, i.e., one or more landcover units represented by a single color on the map. Often several clusters were included in a single map category. In some cases, this was because a

map category included a number of landcover units with different spectral properties (e.g., water, ice, barren and partially vegetated areas). In other cases, there were insufficient ground reference data to define more categories.

The major units described are the ones that could be distinguished during the time available for interpretation in late 1981. We hope that the dissimilar vegetation types now within some map categories can be separated by breaking single spectral classes into several clusters. Digital terrain data are being used to help separate classes on the basis of slope. Class consistency was a primary goal. Care was taken to identify and resolve conflicts between the three Landsat scenes as the final 12 map categories were developed.

Colored Map Preparation

Geometric Correction

Ground control points, i.e., surface features identifiable both on 1:63,360-scale topographic maps and in the Landsat data, were selected for computing the parameters needed for geometric correction of the Landsat data and registration to a UTM projection. About 30 well-distributed control points were selected for each scene. These points were located on USGS 1:63,360-scale topographic maps and on gray-scale line-printer maps produced from the Landsat data at a scale of approximately 1:24,000. The points were used to define second-order least-squares polynomial transformation equations relating latitude and longitude on the maps to row and column numbers on the Landsat scenes. The coefficients in the polynomial equation were used for correcting each scene to a UTM projection (Zone 6) and resampled so that the resulting pixels were 50 meters on a side. The maximum acceptable error before a point was deleted was 35 pixels in either the X or Y direction. Root mean square errors were less than 15 pixels.

Scene Mosaic

Once the data were corrected to a common base, they were digitally mosaicked into a single data set. Common tie-points were identified where the scenes overlapped, and they were used to set mosaic parameters. The resulting mosaic of the classified scenes showed no apparent scene boundaries. This is a good qualitative indicator of the Landsat classification process and the consistency of the spectral class descriptions.

Data Generalization

The original pixel data had a "salt and pepper" appearance with numerous isolated pixels in otherwise homogeneous areas of color. This detracted from the appearance of the map without adding much information at the 1:250,000 scale. Thus, it was desirable to generalize the Landsat pixel data for cartographic presentation.

Accordingly, the data were filtered in an attempt to remove tiny occurrences of map categories one or two pixels in size. The filtering was done by systematically moving a 3- x 3-pixel window across the classified data. In the first round, the center pixel (the one being considered for reclassification) was assigned a weight of 4, while its adjacent neighbors, both horizontal and vertical, were assigned weights of 2, and the pixels on the diagonal were assigned weights of 1. Each map category showing in the window was rated by adding the weights, and the

pixel in question (the center pixel of the group of 9) was assigned to the map category with the highest rating. The window was then moved to the next pixel. This 4-2-1 smoothing process eliminated many isolated pixels while preserving the shape of the remaining units. A second round of filtering was performed on the results from the first with a 2-1-1 smoothing, eliminating more single pixels and creating more homogeneous map area.

Base Map

A base map for the final colored Landsat-derived landcover map was compiled from a mosaic of the four USGS 1:250,000-scale quadrangles (Flaxman Island, Barter Island, Mt. Michelson, and Demarcation Point). Projection information, township boundaries, and geographic names within the ANWR study area are on this map (plate 3). This base map also contains information on the landcover-unit descriptions and on how the map was prepared.

Printing

A tape of the mosaicked Landsat data was used to drive a large-format laser plotter to generate three color-separation plates (yellow, cyan, and magenta) at 1,250,000 scale. Each pixel was reproduced as a matrix of 16 dots to reproduce the desired density pattern for each color. Each 50-meter pixel was plotted at 200 um spot size to achieve the 1:250,000 scale.

The color-separation plates were registered to the base map and used to prepare the Landsat lithograph by a color additive process. The final map, "Vegetation and Landcover, Arctic National Wildlife Refuge, Coastal Plain, Alaska," by W. Acevedo, D. A. Walker, L. Gaydos, and J. Wray, is available from the U.S. Geological Survey as Map I-1443.

Area Summaries

The areas covered by each of the 12 map categories were calculated using a counting algorithm. Data were generated for the areas within three sets of boundaries: (1) the entire ANWR study area, (2) the 89 townships within the study area, and (3) the boundaries of the regional terrain types. (See Part II, "Descriptions of the major terrain types). This was accomplished by digitizing the respective boundaries, registering the boundaries to the Landsat landcover classification, and applying the counting algorithm. The area data were calculated prior to filtering for map generalization.

Simplified Landcover Map

A more generalized map was prepared at the request of USFWS. This map was derived from an earlier unfiltered version of the Landsat-derived landcover map, which contained more isolated pixels than appear on plate 1. Polygons were drawn around large areas with similar dominant landcover. This map (plate 2) is useful as input to small-scale regional or statewide mapping programs.

RESULTS

Landcover Maps

The Landsat-derived landcover map (plate 1) has 12 map categories, which are briefly described in the map legend and explained more fully in table III-2. Several of the colors represent more than one landcover category. For example, dark blue represents three landcover types: Pond/Sedge Tundra Complex, or Aquatic Sedge Tundra, or Shallow Water. In most cases, the landcover types within a single map category are not radically different. The exception is the light-green category (Unit IV), which may represent Dry Prostrate Shrub, Forb Tundra (Dryas river terraces) or Moist/Wet Sedge Tundra Complex. These units have also proved difficult to separate in Landsat studies in the National Petroleum Reserve -Alaska. (Photographs of most of the major landcover units are included at the end of this appended report.)

The map has not been field checked. There currently is no evaluation of the classification reliability by statistical estimators. It is hoped that a thorough field check will be conducted in the summer of 1982.

Area Summaries

The acreages and percentages are given in tables B-2, B-3. and B-5. Table B-3 contains acreage summaries for the entire ANWR study area. The water category in these tables includes the ocean within the study area boundary (plate 1). Table B-2 contains the data for each terrain type. The sum of the areas for all map categories in the five terrain types listed in table B-2 is 1,556,830 acres, and the sum for all map categories in table B-3 is 1,640,626 acres. The difference of 83,796 acres is the amount of ocean within the ANWR study area. Table B-5 contains the data for each of the 89 townships within the study area.

DISCUSSION

We see an urgent need for tundra legends that are compatible at large and small scales; the ultimate goal is a comprehensive mapping system that can be used both for the broad picture and for detailed site-specific studies.

In the past 10 years, we have mapped many areas of the Alaskan Arctic Coastal Plain and have experimented with various map legends, primarily at the scale of 1:6000 (Walker, 1977; Walker and Webber, 1980; Walker and others, 1980; Sohio Petroleum Co., 1981). The mapping system described here has been designed to provide vegetation information for composite mapping approaches, such as geobotanical master maps (Everett and others, 1978; Walker and others, 1980), or the Integrated Terrain Unit approach (Environmental Systems Research Institute, 1980), where additional characteristics of the landscape, such as soils, landforms, and slope, are also mapped. The system has the advantage that it contains only vegetation information, and is independent of soil, landform, altitude, and so forth. Purists may want to separate the site-moisture descriptor, since this is a characteristic of the site; this is easy to do because it always appears in the same part of the vegetation titles.

Plentiful, detailed ground-reference data are the key to the success of any Landsat mapping program. The mapping system and legend described here is a "from-the-ground-up" approach, with its foundation in very detailed mapping

programs that rely on large amounts of accurate ground-reference data (Walker and others, 1980; Webber and others, 1979).

Vegetation classification in Alaska is in a state of healthy turmoil. Several schemes are currently being applied to Alaskan tundra. Probably none of these will gain universal acceptance, but it is safe to say that they will all contribute in some way to a final statewide system. The current lack of a classification applicable to all Alaskan arctic tundra has prompted the development of the system described here. However, our system adds to the profusion of mapping approaches. Table B-7 cross references this system to six other major systems, showing the equivalent units in two other remote-sensor landcover classifications (Anderson and others, 1976; Nodler and LaPerriere, 1977), two wetland classifications (Bergman and others, 1977; Cowardin and others, 1979), and two vegetation classifications (Viereck and others, 1981; UNESCO, 1973).

The ANWR mapping project was perfectly suited for the application of modern technology using Landsat multispectral scanner data and advanced cartographic techniques. A high-quality publishable map of the ANWR study area was produced within 8 months of the beginning of the project. The map is a valuable reference for evaluating the potential impact of seismic operations within the wildlife refuge. The results can also be used as a basis for more detailed habitat studies. Since the data are in digital format, the map can be easily used in geographic information systems. The area measurements are most useful for the environmental descriptions of the major terrain types (Part II) and will also be useful for future studies within township-sized areas.

The legend system is a solution to the current need for a tundra classification. The current system is still being perfected, but it already meets the following criteria:

1. The system is applicable to both large- and small-scale mapping.
2. It consistently applies the same criteria to all community names.
3. It has a consistent method of naming vegetation complexes.
4. It is well suited for specific application to Landsat MSS data.

Part II

DESCRIPTION OF THE ANWR STUDY AREA

The final Landsat-derived landcover classification and the area data, in combination with detailed field observations and information from the literature, were used to describe the ANWR study area. This information is used in the baseline study prepared by USFWS, under Section 1002(c) of ANILCA, for evaluating the potential impact of seismic exploration activities.

GENERAL PHYSIOGRAPHY, CLIMATE, SOILS, AND VEGETATION INFORMATION

Physiography

The study area covers 5,700 km^2 of the Arctic Slope north of 69°34'. It lies between the Canning and Aichilik Rivers (142° W. and 146° W.) and is contained within the White Hills section of the Arctic Coastal Plain physiographic province defined by Wahrhaftig (1965). The terrain is, for the most part, hilly and dissected

by numerous streams that originate in the Sadlerochit, Romanzof, and Franklin Mountains of the Brooks Range.

The coastal area includes a chain of barrier islands that form the seaward limit of the ANWR study area. The coastline itself is irregular and contains many small bays, lagoons, and spits. Extensive mud flats are associated with the Canning, Hulahula, Okpilak, and Jago River Deltas. Most of the coastline is low lying, with only small bluffs less than 3 m high. At Camden Bay, where the land rises more steeply from the sea, there are bluffs up to 8 m high.

Along the coast there are small areas of flat coastal plain with oriented thaw lakes similar to the terrain of the Teshekpuk Lake section (Wahrhaftig, 1965). Most of the coastal plain within ANWR is gently rolling with many small lakes and wet terrain mixed with small areas of uplands. Stream drainage patterns in the hilly coastal plains are better developed than in the flat thaw-lake plains, and the lake basins are contained between intervening small ridges and terrain irregularities. Hilly coastal plain terrain is common between the Hulahula River and Pokok Bay and stretches for about 35 km inland, where the true foothills begin.

The foothills occur west of the Hulahula River to the Canning, and extend across the entire southern portion of the study area, with maximum elevations of about 360 m. A small amount of mountainous terrain, reaching an elevation of 975 m, occurs in the vicinity of Sadlerochit Spring.

There are many river systems. The Canning, Tamayariak, Katakturuk, Sadlerochit, Hulahula, Jago, and Aichilik Rivers have braided drainages and deltas that collectively cover a large portion of the ANWR study area.

Climate

The only regularly observed climatic data from the study area is from Barter Island (table B-4). This station lies within a belt of strong coastal marine influence, and, in summer, it has fog during about 25 percent of the hourly observations. This is not typical of much of the study area. The inland portions of the study area likely experience warmer summer weather similar to that recorded by Haugen and Brown (1980) along the Trans-Alaska Pipeline. However, direct extrapolation of these data to the ANWR study area is not possible because of variations due to differences in terrain elevation and proximity to the sea. Observations during our brief study in 1981 indicate that inland areas are somewhat colder and wetter than areas at similar distance from the sea in the Prudhoe Bay region (Brown and Haugen, 1979; Walker, 1981). Cumulus buildup and thunderstorms are also more common than farther west. This is due to the nearby high mountains of the Brooks Range.

Soils

Nearly the entire study area being considered here falls within the Coastal Plain Land Resource Region as defined in the Exploratory Soil Survey of Alaska (Rieger and others, 1979). Within this region, the survey recognized two soil associations (i.e., "segments of the landscape with a distinctive topographic and soil pattern): (1) Pergelic Cryaquolls-Histic Pergelic Cryaquepts, with loamy textured mineral components occurring on nearly level to rolling topography; and (2) Pergelic Cryaquepts on nearly level topography with very gravelly mineral components. The first unit occurs on the broad foothills and the coastal plain

portions with thawlakes, and the second occurs on the braided river valleys and their associated terraces and deltas. To date, no detailed regional soil survey exists for any portion of Alaska north of the Brooks Range, with the exception of the Prudhoe Bay production area (Walker and others, 1980) and the Ogotoruk Creek watershed (Holowaychuk and others, 1966). In 1962 Brown (1962, 1966, 1969) developed a soils-landform map for approximately 19 km^2 in the Okpilak River area and described soils between the Jago and Hulahula Rivers. In 1974 Janz (Hellinger and Janz, 1974) decribed, in the course of route selection studies for Alaskan Arctic Gas Study Company, several soils from the foothills near the Kongakut, Aichilik, and Okerokovik Rivers and from the flood plain of the Canning River.

Vegetation

The Foothills and Arctic Coastal plain of Northern Alaska are in the tundra region of the Arctic as defined by Aleksandrova (1980). In the tundra region, mesic habitats are mostly continuously vegetated with low-growing plants, such as sedges, grasses, mosses, lichens, small herbs, and dwarf shrubs. Taller shrubs are restricted to drainages that are protected from winter winds and snow abrasion, and also to slopes with southerly exposures where the amount of solar radiation is maximized. Aleksandrova (1980) contrasts the tundra region with the polar desert region, which occurs at more northerly latitudes and where the plant cover is continuous only in wet sites. On the 1:2,500,000 major ecosystem map of Alaska (Joint Federal State Land Use Planning Commission, 1973) most of the study area is mapped as Moist Tundra, with several small areas dominated by Wet Tundra and High Shrub occurring along the streams. The problems with this map are discussed later in this paper. The general character of Alaska arctic vegetation has been thoroughly described by Britton (1957), Wiggins and Thomas (1962), and Spetzman (1959). Hettinger and Janz (1974) studied several sites within the study area as part of the survey work for the Arctic Gas pipeline route. The vegetation and soils are described more thoroughly for each terrain type within the discussion section of this report.

METHODS

Landsat Classification

The methods employed for the Landsat classification are those available at the USGS Geographic Investigations Office at Ames Research Center, Moffett Field, California. They were described by Morrissey and Ennis (1981). Ground-truth information is acquired and used with aerial photography to identify classes resulting from subjecting the Landsat multispectral data to a clustering algorithm on a computer.

Three Landsat scenes were selected for analysis. The eastern two-thirds of the region were covered by scene 22008-20420 (22 July 1980) acquired from the Canada Centre for Remote Sensing after a check of the data base showed that it was unavailable from U.S. ground stations. Most of the remainder of the region was covered by scene 21633-20531 (13 July 1979), while a small wedge in the extreme southwest was picked up on scene 2570-20642 (14 August 1976). Differences in spectral response from scene to scene and in phenological changes in vegetation from year to year, owing chiefly to different moisture regimes, necessitated that each scene be treated separately in the analysis process.

A systematic 10-percent sample of each Landsat scene was used to select pixels for clustering, a process that sorts the Landsat data into classes whereby pixels with each class are as similar to each other as possible, and whereby pixels from different classes are as different from each other as possible. These clusters describe in statistical terms (means and covariances) the spectral properties of Landsat data (Swain, 1972). From past experience, it was expected that these clusters would describe only general landcover types and not the specific ones desired. Therefore, full advantage was taken of the ground-truth data. (See Methods, Ground Truth.) Landsat pixels from each of the four visited townships were clustered separately. Resulting clusters were used to define vegetation classes, whereas the 10-percent clustering was used to select clusters representative of ice, water, and barren land.

It was found after an initial examination that some vegetation classes were still not well defined by clusters. These were classes that occurred rarely in the areas studied and, hence, tended to be described by clusters having high variances that included several similar spectral types. To handle these special cases, known occurrences were defined and mapped from the ground-truth information. Landsat pixels from these locations were then clustered independently, without consideration of other classes in the area, to produce sharper spectral classes.

All these clusters were examined for each scene, and an analyst made decisions concerning which clusters to keep, delete, or merge before using them in the classification process. These decisions were made on the basis of an analysis of the spectral statistics, especially measurements of cluster separability. In general, an attempt was made to utilize clusters that described statistically well defined vegetation types with a minimum of conflict among the various clusters in terms of special overlap.

Once a set of statistics was defined for each scene, maximum likelihood classifications were run. Spectral reflectance values for each pixel were used to calculate a discriminant function for each class, and each pixel was assigned to that class for which the discriminant function was greatest (Gaydos and Newland, 1978). In this way, all pixels were classified into spectral classes defined by the clusters.

Results were viewed on a color image display. Using the display, the analyst was able to view selected portions of the Landsat scene and give each spectral class a distinctive color while he tried to identify the vegetative characteristics of it based on field notes and high resolution aerial photography. This interpretation step was most important and was aided immensely by the prior field experience.

Each of the clusters was interpreted and identified as to landcover unit. Since a given unit may have several slightly different spectral types, several clusters were often used to define one landcover unit. Class consistency was important, and care was taken in looking for and resolving conflicts between Landsat scenes in developing the final 12 landcover units.

Control points, features identifiable on a map and in the Landsat data, were selected to compile parameters needed for geometric correction of the data. About thirty, well-distributed points were selected for each scene based on the 1:63,360-scale topographic maps and gray scale prints from the Landsat data produced on a lineprinter at approximately 1:24,000 scale. These control points were used to define second-order least-squares polynomial fits between pixel

coordinates and geographic coordinates. Parameters were calculated from these polynomials for correcting each scene to a UTM projection (Zone 6) and resampled so that resulting pixels were 50 meters on a side.

Once the data has been corrected to a common base, they were digitally mosaicked into one data set. Common tie-points were identified in the overlap regions and used to set mosaic parameters. Because of the consistency of the classification from scene to scene, the resulting mosaic of the classified scenes showed no apparent scene boundaries.

Though Landsat pixels were transformed into 50-m cells registered to the UTM projection, it was desirable to generalize these data for cartographic presentation. Accordingly, the data were filtered in an attempt to remove tiny occurrences of landcover units (small polygons one or two pixels in size). A three-by-three matrix centered on the pixel in question was used to define the filtering parameters. In the first round, the center pixel (the one being considered for reclassification) was assigned a weight of 4 while its adjacent neighbors, both horizontal and vertical were assigned weights of 2, and the diagonal weights of 1. Each landcover unit within the matrix was rated by accumulating weights, and the pixel in question was assigned to the class with the highest weighted ranking. The matrix continually moved to surround and decide on the class for every pixel. This 4-2-1 smoothing process tended to eliminate many singly occurring pixels while preserving shapes of the remaining units. A second round was performed on results from the first with a 2-1-1 smoothing that cleaned up many more small polygons.

Meanwhile, a special base map was compiled from a mosaicking of four USGS 1:250,000-scale quadrangles (Flaxman Island, Barter Island, Mt. Michelson, and Demarcation Point). Projection, land net, and geographic names were all plotted within the bounds of the ANWR Coastal Plain region. This special base also contained information on how the map was prepared, and the landcover class descriptions.

A tape of the mosaicked Landsat data was used to drive a large format laser plotter to generate three color-separation plates (yellow, cyan, and magenta) at 1:250,000 scale. Each pixel was reproduced as a matrix of 16 dots, each black or white to reproduce the desired density pattern for each color. Each matrix (50-meter pixel) was plotted at 200 microns to achieve the 1:250,000 scale.

These color-separation plates were registered to the base map and used to lithograph the map, using yellow, cyan, magenta, and black in a color-additive process. The final map, Vegetation and Landcover, Arctic National Wildlife Refuge, Coastal Plain, Alaska, 1982, is available from the U.S. Geological Survey as Map I-1443 and is included in the EIS as plate 1.

Each landcover unit, represented by a single color on the map, includes several vegetation types, sometimes dissimilar ones, as will be described in the following section. The major units described are the ones that we are able to separate from each other with Landsat data during the time available in late 1981. It is hoped that dissimilar vegetation types presently within the same landcover unit can be separated by breaking single spectral classes into several clusters. Digital terrain data is also being employed to help separate classes on the basis of slope information.

Measurements were made of areas occupied by the 12 landcover units for the entire mapped area, regional terrain types, and townships. These were produced by digitizing boundaries of each, registering the boundaries to the Landsat classification, and running a counting algorithm. Areas occupied by each landcover unit were calculated from the data prior to filtering for final cartographic presentation.

Ground Truth

Ground-truth information for the project was gathered during a USFWS-supported helicopter survey, 12-17 August 1981. The survey was concentrated in four townships (fig. III-3) that appeared to represent the major landform features within the ANWR study area. This information was supplemented with extensive ground truth from similar Arctic Alaska areas outside ANWR gathered during the past during the past several years. Vegetation of these sites was then delimited on 1:60,000 scale color infrared (CIR) photographs (flown in 1978 and 1979 by NASA).

The field method consisted of locating large homogeneous areas of terrain on the CIR photographs and then describing from the air the vegetation physiognomy (e.g. wet sedge tundra; dwarf shrub, tussock sedge tundra; partially vegetated, etc.), and the landform (e.g., low-centered polygons, strangmoor, water tracks, etc.). At particularly homogeneous areas or areas that appeared to be representative of common units, detailed notes were obtained for the vegetation, site factors, and soils. Each area was photographed from the air and on the ground. Plants collected during this survey will be given to the University of Colorado Herbarium. Readers unfamiliar with the U.S. Soil Taxonomy should consult "General Characteristics and Taxonomy of the Principal Soils Within the ANWR" in this appendix and Soil Survey Staff (1975) for explanation of soil terminology.

MAP LEGEND

Nomenclature

The landcover unit names are based on the growth forms of the dominant plants and site moisture. The names may appear to be excessively lengthy, but they are derived according to a consistent system of nomenclature that can be applied to any tundra landscape. In some cases, shorter synonomous names can be used for convenience.

At small scales, plant physiognomy is the character of the vegetation that is most universally used in mapping (Fosberg, 1967; Kuchler, 1967; UNESCO, 1973). We use nine basic plant growth-forms for describing tundra vegetation: (1) tall shrubs (greater than or equal to 2 m tall); (2) medium shrubs (0.5 to 2 m); (3) dwarf shrubs (0.1 to 0.5 m); (4) prostrate shrubs (less than 0.1 m); (5) tussock graminoids, non-tussock graminoids; (6) forbs; (7) mosses; and (8) lichens, plus a barren category. The graminoid vegetation is usually further broken into either sedge or grass-dominated units; and lichen vegetation is often broken into crustose of fruticose-foliose dominated units. We characterize the moisture regime of the site as dry, moist, wet (saturated soil, water greater than 10 cm deep) or aquatic (deeper permanent water).

Vegetation that is dominated by more than one growth form, where each growth form has at least 30-percent ground cover when viewed from the air, can have more than one growth form in its name (e.g., Moist Tussock Sedge, Dwarf

Shrub Tundra). The moisture term always precedes the growth forms, and the term tundra is used for all arctic or alpine vegetation that has more or less continuous ground cover.

Vegetation Complexes

In many tundra areas, complexes of vegetation occur. These are units where more than one vegetation community occurs, usually in a non-random pattern, associated with such features as ice-wedge polygons, frost boils, strangmoor or solifluction features. On Landsat imagery it is necessary to use complex map units because the area covered by individual pixels (about 0.5 hectare) is greater than the size of most areas of homogeneous tundra vegetation. In the Arctic, distinct community mosaics occur mainly as a response to minor elevation differences associated with patterned ground. Most of the individual communities are too small to map even at the 1:6000 scale. If the map or pixel unit contains two or more distinct communities, where each community covers at least 30 percent of the map unit, then the unit is considered a complex. The term "complex" is attached to the end of the landcover name, and the major elements of the complex are separated by a slash (/). For example, a map unit composed of Wet Sedge Tundra and Moist Sedge Tundra is called a Wet/Moist Sedge Tundra Complex. The first named portion of the complex is the most abundant. A map unit with a wet dwarf shrub community occurring in the water tracks of tussock sedge, dwarf shrub tundra would be named Moist Tussock Sedge, Dwarf Shrub/Wet Dwarf Shrub Tundra Complex. The term "water-track complex" could be used as a shorter synonym.

Compatibility with Large Mapping Scales

At large scales, the dominant plants in the vegetation units may be added to the name by inserting the dominant plant taxa between the moisture term and the growth-form titles, e.g., MOIST Eriophorum triste, Salix arctica, Dryas integrifolia, Tomenthypnum nitens, Thamnolia subuliformis. SEDGE, PROSTRATE, SHRUB TUNDRA. Usually one or more dominant taxa are included from the shrub, herb, and cryptogam components of the vegetation, the total number of taxa not exceeding six. The taxa are kept to the minimum number required to adequately distinguish the community from others on the map.

Complexes of vegetation at large scales are usually described by the nature of the landform on which the complex occurs. For example, vegetation occurring in a wet low-centered polygon complex would have the following explanation in the legend. (See also table B-1.)

WET/MOIST LOW-CENTERED POLYGON VEGETATION COMPLEX:

a) Wet microsites: WET Carex aquatilis, Scoripidium scorpioides SEDGE TUNDRA

b) Moist microsites: MOIST Eriophorum triste, Dryas integrifolia, Salix arctica, Tomenthypnum nitens SEDGE, PROSTRATE SHRUB TUNDRA

Derived Terrain and Vegetation maps

Two derived maps were prepared from the 1:250,000 Landsat classification. The first is a terrain type map (fig. III-3) which was made by drawing boundaries around units with similar terrain. This was interpreted using a combination of the

Landsat product and USGS topographic maps. The second was a derived vegetation map based on the Landsat landcover map (plate 2). Polygons were drawn around groups of pixels with same color. This map was requested by the USFWS because of the advantage that distinct polygons have for certain habitat studies. It was prepared in the Plant Ecology Laboratory at INSTAAR.

RESULTS

Landsat Landcover Classification

The Landsat landcover map (plate 1) contains 12 landcover classes, which are briefly described in the map legend and more fully in table III-2. Several of the colors on the map represent more than one distinct landcover category. This is caused by similar spectral signatures for some of the categories. This is not a particularly severe problem since in most cases the categories are not radically different. The one exception is unit IV where there is confusion between the Dry Prostrate Shrub, Forb Tundra (Dryas river terraces) and Moist/Wet Sedge Tundra Complex.

Derived Maps

The derived terrain-type map is shown as figure III-3. The derived vegetation map (plate 2) contains the same units as the Landsat map. The map was prepared from an earlier version of the Landsat map, before isolated pixels were removed and the units generalized. (See Methods, Landsat Classification.) In some cases, units on the derived vegetation map appear different than those on the Landsat map. This is due to judgment decisions regarding the dominance of pixel colors within polygon boundaries. In a few cases, the Landsat color was changed (e.g., where ice occurred on lake surfaces). Generally, however, the Landsat map (plate 1) should be considered the more accurate of the two.

Planimetry Data

Planimetry totals are in table B-2. Tables B-3 and B-5 contain acreage summaries for the coastal plain portion of ANWR. It should be noted that the water category in these tables include the ocean within the study area boundary. (See fig. III-1.) Table B-2 contains the planimetry data broken down by terrain type and by landcover units. The values for each landcover unit within a terrain type include acre cover, hectare cover, percentage of the terrain type, and percentage of entire study area. It should be noted that the sum of all landcover units within the terrain types is 1,556,830 acres, and the sum for all landcover units in table B-2 is 1,640,626 acres. The difference of 83,796 acres is the cover of ocean within the ANWR study area.

DISCUSSION

Landform, Soils, and Vegetation in the Major Terrain Types

The major terrain types within the ASNWR study area can be treated as distinct ecological units with representative suites of vegetation soils, and landforms. The following discussion summarizes the geobotanical features within each terrain type.

Flat Thaw-Lake Plain Terrain

Topography and Landforms

The proximity of the Romanzof and Sadlerochit Mountains to the coast results in a much narrower belt of coastal plain than is found farther west, such as along the Trans-Alaska Pipeline and in the National Petroleum Reserve in Alaska (NPRA). In fact, the typical coast plain topography with large oriented thaw lakes, drained lake basins, and expanses of low-centered, ice-wedge polygons is found in only a few small areas, primarily near the flat braided deltas of rivers (fig. III-4). These areas are best developed in the delta of the Canning River and for some 12-15 km eastward in a narrow coastal belt as well as in a narrow zone between the delta of the Hulahula River and a point some few kilometers east of the Jago River. Barter Island is included in this zone. With the exception of the delta area of the Canning River, the thaw-lake plains appear to be remnants of a once more extensive plain. They are topographically similar to the thaw-lake plains east of the Canning River being composed of up to 30 percent water confined to small (generally less than 260 ha) shallow, elliptical oriented lakes. Areas between the lakes are poorly drained as a result of a very low surface hydraulic gradient and a thin active layer. Except for the basins of relatively recently drained lakes, some form of microrelief is nearly always present. It consists mostly of low-centered non-orthogonal polygons, strangmoor, or complexes of disjunct low-centered polygons with pond complexes. Flat thaw-lake plains comprise only about 3 percent of ANWR.

Soils

The area is underlain by ice-rich permafrost at depths of about 40 cm. Except for polygon rims the perched water table is very close to the surface or slightly above it for most of all of the thaw period. Fibrous Histic Pergelic Cryaquepts or occasionally Histic Pergelic Cryaquolls and Pergelic Cryaquepts are common to the wet and very wet areas. Pergelic Cryaquolls occur on the more mesic polygon rims. The soils are all neutral to slightly alkaline in reaction, even the saline fibrous Histic Pergelic Cryaquepts and Cryohemists inundated by storm surges along some coastal areas.

In general, the soils of the flat thaw-lake plains are similar to those described in the Prudhoe Bay region (Everett and Parkinson, 1977; Parkinson, 1978; Everett 1980a), and Barrow (Drew, 1957; Drew and Tedrow, 1957; Ulrich and Gersper, 1978; Gersper and others, 1980).

Vegetation

The vegetation of the thaw-lakes plains is similar to that described at Barrow (Tieszen, 1978; Brown and others, 1980), Fish Creek (Lawson and others, 1978) and Prudhoe Bay (Webber and Walker, 1975; Walker and others, 1980; Walker, 1981). The dominant Landsat landcover categories are Wet Sedge Tundra (46 percent cover), (fig. B-17 and table III-2, unit III), Water (19.5 percent cover), Moist/Wet Sedge Tundra Complex (12.7 percent cover) (figs. B-18 and B-19 and table III-2, unit IV, Aquatic Tundra and Pond Complex (8.4 percent cover) (fig. B-20, and table III-2, unit II). Microtopography on a scale of less than 1 m of elevation difference plays the major influence on the distribution of communities. The small elevation differences associated with ice-wedge polygons create distinct patterns of plant communities and soils that are associated with the various topographic elements

within individual ice-wedge polygons (Wiggins, 1951; Cantlon, 1961; Britton, 1957; Walker, 1981).

Patterns of plant succession in the flat thaw-lake plains are intimately linked to the oriented thawlake cycle (Hopkins, 1949; Britton, 1957; Carson and Hussey, 1961; Everett, 1980b; Walker and others, 1981). Although much has been written regarding thaw-lake mechanisms, the cycle and successional patterns are still incompletely understood (Mackay, 1963). Probably the biggest questions regard the time scale; for example, how long it takes for the cycle to operate, and how long has the present wet coastal plain environment existed.

Summer temperature is of primary importance with respect to vegetation near the coast. A steep temperature gradient is associated with the coastal strip. Data from Prudhoe Bay and along the Trans-Alaska Pipeline show that mean July temperatures at the coast are within a few degrees of freezing, due to the ice-covered Beaufort Sea; more moderate temperatures are found inland (Conover, 1960; Cantlon, 1961; Haugen and Brown, 1980; Walker, 1981). Low levels of radiation are associated with coastal fog. Low amounts of total summer warmth are primarily responsible for a distinctive band of coastal vegetation that has few shrub species, limited tussock formation, reduced moss and lichen growth and few species in the total flora (Cantlon, 1961; Clebsch and Shanks, 1968; Walker, 1981). This band of coastal tundra, which Cantlon (1961) terms "littoral tundra," lies north of the 7°C July mean isotherm. Worldwide, this zone is equivalent to the arctic subregion of Aleksandrova's (1980) tundra region. At Prudhoe Bay, the coastal strip is about 25 km wide; near Barrow it is about 100 km wide. It is less than this within ANWR because of the narrowness of the coastal plain and a more compressed coastal temperature gradient.

Along the northern limit of the "littoral tundra" band, there is yet another band of vegetation that is associated with the saline soils found immediately adjacent to the coast. This area is affected by tidal influences, windblown salt spray, and occasional storm surges that flood large areas of inland tundra. Taylor (1981) divides this shoreline vegetation into six habitat types: tidal salt marsh (fig. B-21), upper storm zone salt marsh, gravelly beach, raised bench, coastal dunes, and coastal bluffs. Coastal vegetation in northern Alaska has been describedf by Jefferies (1977), Walker (1981) and Taylor (1981). Within ANWR it has been studied by C. Myers (1981) in the Beaufort Lagoon area.

The immediate coastal areas are characterized by sand and gravel beaches, spits, and bars. Such features, although a small percentage of the study area, are locally important for the numerous birds that utilize these areas. Vegetation is for the most part sparse due to the very unstable substrate. A few species such as Honcrenya peploides (Sea Purslane), Mertensia maritima (Oysterleaf) and Cochlearia officinalis (Common Scurvy Grass) grow on slightly protected beach gravels. Some of the islands have small areas of tundra that are remnants of what existed when the islands were part of the mainland. Soil development on the beaches is either lacking or in some sites Cryorthents are recognized.

Hilly Coastal Plain Terrain

Topography and Landforms

Stretching inland between the Hulahula and Jago Rivers from the flat thaw-lake plain is a complex region of very gently undulating tundra with small thaw

lakes and pond complexes (HCP in fig. III-3). This area is quite different from the flat coastal plain areas with large oriented thawlakes. Stream drainages are more defined and large expanses of well-drained terrain border many of the streams. Elevations within the region rise gradually from near 30 m to about 100 m. East of the Hulahula River, there are numerous slightly elevated ridges and depressions, mostly with less than 30 m of relief contrast, that parallel the coast (fig. III-5). The origin of these ridges is uncertain. On aerial photographs they appear to be either beach terraces from past marine transgressions or, possibly, they reflect underlying structural features or sand dunes. These features are evident on 1:250,000 topographic maps and the Landsat classification of the region (plate 1). They occur up to 200 m elevation on the northern flank of the foothills. Flat interfluve areas contain complexes of wet and moist tundra associated with poorly developed ice-wedge polygons.

Some areas, such as that along the western side of the Niguanak River and the coastal area just south of Pokok Bay, have more hilly terrain with well-developed drainages. The vegetation and landforms here closely resemble that of the foothills terrain type except the hills are less steep and thermokarst pits are more extensive on the broad hill crests. Hilly coastal plain terrain covers 22 percent of the ANWR study area.

Soils

Soils on the ridges and gently sloping areas are similar to those in the foothill terrain type (described in the next section), while soils in the depressions resemble those of the flat thaw-lake plains. The gently sloping (5 percent or less) interfluves have mostly moist tussock tundra with flat-centered polygons. Frost scars occupy greater than 30 percent of most surfaces and are considered to have Pergelic Cryaquept soils with loam and fine sandy loam textures. Soils between the frost scars are Pergelic Cryaquolls and commonly have from 1-12 cm of sapric organic surface horizon overlying loam, or occasionally silt loam textured mineral soil. The active layer is 35 to 45 cm deep in August. A water table does not develop in the polygon centers but may develop in the narrow troughs between polygons where soils in these areas are (fibric) Histic Pergelic Cryaquepts.

Vegetation

The vegetation, like the landforms and soils, is a hybrid between the flat thaw-lake plain and foothill terrain types. Vegetation on the ridges is mainly Moist Sedge-Prostrate Shrub Tundra (table III-2, unit Va) that may or may not contain cottongrass tussocks. The dominant Landsat landcover categories are Moist Sedge-Prostrate Shrub Tundra and Moist Sedge-Barren Tundra Complex (table III-2, unit V). The latter category is associated mainly with uplands with frost-scar terrain (fig B-22; table III-2, unit Vb). This unit covers 37.6 percent of the hilly coastal plain terrain type. Moist/Wet Sedge Tundra Complex is also important, covering 33.5 percent of the hilly coastal plain terrain type. The depression between ridges contain thaw lakes (about 3 percent cover) and wet tundra (22.7 percent cover).

Foothills

Topography

Foothills (fig. III-6) cover about 45 percent of the area of interest. The hills are typically characterized by rounded, north-trending interfluves between the

major drainages. Elevations of the hilltops range from 90 meters at the coastward boundary to about 375 m at the southern limit of the province. These major interfluves are subdivided into a finer textured pattern of subparallel drainages. Superimposed on the north-south pattern is one that trends generally east-west reflecting the strike of the underlying Cretaceous or Tertiary sandstones and shales. Outcrops of some of the flatter lying, more competent units produce mesalike elements on the interfluves (fig. B-5) while dipping strata produce discontinuous linear trends.

Between the Canning River and the Sadlerochit River, an east-west distance of about 75 km, low foothills rise from Camden Bay by the base of the Sadlerochit Mountains, which are 30 to 55 km from the seacoast. The hills in this region are up to 380 m high and are interspersed with the drainages of the Tamayariak River, Katakturuk River, Marsh Creek, Carter Creek, Itkilyariak Creek, and the Sadlerochit River. The crests of several hills, particularly in the vicinity of the Katakturuk River, have barren gravel outcrops (fig. B-6). These hills are physiographically and geologically similar to the White Hills and Franklin Bluff. East of the Sadlerochit River, the foothills are farther from the coast. In the vicinity of the Jago River, which is the widest part of the coastal plain within the refuge (fig. III-1), the coastal plain is about 40 km wide and there are another 20 km of foothills to the refuge-wilderness boundary.

It is likely that at least the southern parts of the north-trending interfluves were sculptured by the early Pleistocene glaciers advancing from the Brooks Range. Although moraines associated with the latter ice advances can be found near the mountain front; the extent of ice-deposited materials on the interfluves is uncertain. Also, the extent to which the area has been inundated by interglacial marine transgressions is unclear, but it seems likely that such deposits may extend a considerable distance inland, especially east of the Okpilak River.

Landforms and Soils

Interfluves throughout much of the area are elongate convex features or nearly flat, mesalike forms. In either case, the crests are commonly sites of complex patterns of soils and microscale landforms (figs. B-7 and B-8) e.g., areas of tussock-covered high-centered polygons juxtaposed with patternless areas, strangmoor, and low-centered polygons. Thermokarst pits are a common adjunct and indicate substantial amounts of wedge ice. The better drained elements of the landscape, i.e., the raised-centered polygons, have Cryaquoll soils with up to 12 cm of hemic or sapric organic overlying dark-colored organic-rich mineral material; Cryaquepts occur as frost scars that may occupy up to 40 percent of the polygon surface. Mineral horizons of both soils are loams or fine sandy loams with variable amounts of pebbles. Active layer thickness ranges from near 30 cm beneath the Aquolls to greater than 60 cm beneath the Aquepts. A water table is absent or well below the surface. The wet areas commonly have Histic (greater than 20 cm of fibrous organic) Pergelic Cryaquolls or Histic Pergelic Cryaquepts if colors (and organic carbon content) below the histic epipedon do not conform to the criteria for the mollic epipedon. In either case a water table occurs at or above the surface and permafrost is between 40 and 45 cm. In the wettest areas there is enough buoyancy in the fibrous organic root-rich mat that its true thickness is difficult to determine. Relatively dry areas which include prominent (greater than 50 cm high) rims of low-centered polygons and some high-centered polygons have Histic Pergelic Cryaquolls with a sapric organic horizon. Permafrost is generally between 20 and 30 cm and no water table develops.

Hillslopes are generally greater than 5 percent and covered with cottongrass tussocks. Parallel and subparallel water tracks are commonly present giving the topography a decidedly ribbed appearance (fig. B-26). Areas referred to as water tracks are shallow vegetated channels that conduct snow melt waters and perhaps subsurface waters as well during the thaw season. Strangmoor are often found in the channels suggesting slow mass movement of the saturated soil. Willow and birch are concentrated in these features and impart distinct color patterns on color-infrared photographs in summer and on standard color film in the fall. The inter-water-track areas are tens to hundreds of meters wide, convex to the adjoining track and from 0.15 to 1 m above the track. The water track portion of the slope presents a relatively smooth and graded cross-section. Polygonal outlines are usually not apparent and the forms generally lack microrelief contrast. Ice wedges may still be extensive beneath such slopes. Soils are Pergelic Cryaquolls or Pergelic and Histic Pergelic Cryaquepts. (The latter soil is not common (fig. B-15).) In most cases 4-15 cm of hemic or sapric organic matter overlie mineral materials into which organic material is commonly enmixed. Active layer thicknesses range between 30 and 50 cm. The presence of a water table is uncommon. Histic Pergelic Cryaquepts are most common within the water tracks. Active layer thickness here is between 40 and 50 cm and water table is almost always present, commonly with 10 cm of the surface.

Frost scars are almost always a component of tussock tundra and can comprise up to 50 percent of a given surface with anywhere from a few percent to 75 percent showing some activity (i.e., having bare mineral soil exposed). It is a common occurrence where slope breaks occur that both the density and activity of frost scars increases. In such cases 65-80 percent of surface may be comprised of active frost scars. Frost-scar soils (fig. B-22) are composed of grayish-brown, usually mottled sandy-textured mineral material. The lack of discernible profile development should dictate placement within the Entisols (possibly as Cryorthents) however, under the present system the soil pedon is considered as a Rutpic-Entic Cryaquoll.

Where bedrock is very close to the surface, as shown in figure III-7, frost scars, and/or patterned lag gravel may comprise 70 to 80 percent of the surface. Because of the exposed nature of such surfaces, snow cover is thin or absent and abrasion by blowing snow may be severe. However, soil development beneath stable microsites may be relatively intense. The soils are Pergelic (Lithic) Cryumbrepts if sufficient enmixed organic matter is present or Pergelic (lithic) Cryochrepts if it is not. Active layer thickness is greater than 1 m and ice volumes beneath are generally low.

Solifluction forms such as discontinuous stripes of frost scars or lobes are common downslope from some outcrops and where slope breaks exceed 7 to 10 percent. This is due principally to the water added from snowbank melt. Microrelief is relatively great, which when combined with the high moisture environment, makes such areas quite susceptible to vehicular impacts.

Vegetation

Vegetation in the foothills is predominantly Moist Tussock Sedge, Dwarf Shrub Tundra (figs. B-23, B-24,and table III-2, unit VI). Unit VI covers 53.8 percent of the foothills terrain type. In some areas, the shrub vegetation is dominant and the landcover class is a Moist Dwarf Shrub, Tussock Tundra (fig. B-25 and table III-2, unit VIIa).

The vegetation in the water tracks (also called horsetail drainages by Cantlon (1961)) is often dominated by dwarf shrubs, mainly dwarf birch (Betuyla nana) and diamond-leafed willow (Salix planifolia ssp. pulchra). Landcover with water track complexes is generally classed as Moist Tussock Sedge, Dwarf Shrub/Wet Dwarf Shrub Tundra Complex (table III-2, unit VIIc).

A few steep, mainly south-facing slopes, have well-developed shrub tundra (fig. B-27, table III-2, unit VIII). Dense shrub tundra with a sedge understory occurs along many stream margins.

Tussock tundra can have a bewildering array of subtypes that are difficult to classify. These are related to a number of factors such as slope stability, soil moisture, cryoturbation, and successional history. Successional patterns related to fire have recently been described by Racine (1981). The effect of frost activity is of primary importance (Sigafoos, 1951; Hopkins and Sigafoos, 1951; Racine and Anderson, 1979).

Within the study area frost scar tundra is widespread in the foothills. In areas underlain by neutral or slightly alkaline soils, this has important implications for the vegetation. Upland tundra is normally acidic due to the thick layers of organic matter and the accumulation of organic acids in the peat. Sphagnum moss, numerous eriaceous shrubs, and other bog species such as Cloudberry (Rubus chamemorus), are adpated to life in an acidic environment. When the soil pH becomes more alkaline, many of these species cannot survive and are replaced by a different suite of upland tundra plants, mainly Arctic Avens (Dryas integrifolia), Bigelow's Sedge (Carex bigelowii), the moss Tomenthypnum nitens, the Wooly Willow (Salix lanata), and the grass Arctigrostis latifolia. Frost-scar tundra most commonly occurs on hill slopes associated with the numerous streams in the foothills, and is particularly common in the foothills of the western part of the study area. The broad tops of gentle hills are usually more stable, peat accumulations thicker, and the tundra is consequently acidic with abundant cottongrass tussocks (Eriophorum vaginatum) and dwarf shrubs such as Dwarf Birch (Betula nana), Diamond-leafed Willow (Salix planifolia ssp. pulchra), Labrador Tea (Ledum decumbens), Bog Blueberry (Vaccinium uliginosum) and Mountain Cranberry (V. vitis-idaea).

Unfortunately, on the present Landsat classification, it is not possible to distinguish frost-scar tundra (unit V6) from the Moist Sedge, Prostrate Shrub Tundra (unit Va, table III-2). Generally, the latter type occurs in stream drainages and on open moist tundra near the coast where tussocks and dwarf shrubs are not extensive.

East of the Hulahula River, there is a noticeable boundary between Landsat Units V and VI that corresponds approximately with the break in slope between the flatter plain and the foothills. (See plate 1.) The cause of this boundary is not presently known, but it may represent a difference in the substrate. Possible unit V is dominant on the marine deposits of the lowlands while unit VI is dominant on the sandstone and shale based substrates of the foothills.

Alpine Areas

Landforms and soils

Only a small amount of alpine terrain occurs in the study area (about 0.05 percent) (fig. III-8). Of principal interest is an area of a few square kilometers, mostly above 600 m elevation, in the vicinity of Sadlerochit Spring (fig. B-12). This area is part of the limestone rocks that comprise the major outcrops of the Sadlerochit Mountains, and the terrain is generally similar to other limestone alpine areas in the Brooks Range.

An idealized section of alpine terrain is shown in figure B-13. Ridge crests have only sporadic occurrences of soils and vegetation and a complex of ground patterns and rock land. Soils on ridges are mainly Pergelic Cryothents, or Cryumbrepts (fig. B14), if the textures are fine enough, mixed with frost features and rock land. Upper steeper portions of most alpine slopes are mantled by scree or blocky talus. These deposits commonly display block stripes and/or block bordered terraces. It is common that ice fills the interstices of the finer cobble and gravel size fragments below the large surface blocks. Pockets of Pergelic Cryumbrepts, Cryochrepts, or on occasion, Pergelic Cryaquolls do occur in finer textured materials. Their presence and degree of development argue for at least local stability or very slow rock glacier movement on such slopes.

Although permafrost is present beneath such surfaces it is difficult to detect since the free drainage and exposed snow-free position precludes any significant accumulation of ice. However, experience elsewhere has shown (Everett, 1967) that ice may be present in some quantity in bedrock fractures.

Downslope from the talus, where vegetation cover is commonly complete and snowbanks develop, the slopes display a variety of solifluction forms including turf-banked terraces, lobes and stripes. A complex of soils is found on such slopes that includes Pergelic or Histic Pergelic Cryaquepts in wet depressions, Pergelic Cryaquolls on somewhat better drained terrace or lobe fronts and occasionally Pergelic Cryohemists or Cryosaprists where slow deformation has produced folded and over-thickened organic horizons. Active layer thickness on such slopes varies considerably, ranging to 70 cm or more in the wetter areas to less than 30 cm on some of the better drained microtopographic elements with organic-rich soils. Where coarse blocky talus underlies the solifluction slope, water movement may cause piping and the distribution of mineral material over the surface of otherwise organic-rich soils. Solifluction slopes are naturally unstable with a complex of perched water tables and subsurface drainage and are very susceptible to vehicle traffic that can produce mechanical and thermal erosion.

Vegetation

Vegetation communities in alpine areas are complex and interspersed with unvegetated rocks and talus slopes. The character of the well-vegetated slopes varies considerably, but the more completely vegetated areas have extensive moss mats with numerous small shrubs, such as mountain avens (Dryas octopetala), and prostrate willows (Salix arctica, S. chamissonis, S. phlebopohylla), and small forbs. (See table III-2, unit IXb, Partially Vegetated Areas, Alpine Tundra.) Limestone areas are of particular interest because of the presence of unique assemblages of

plants such as the bryophytes associated with wet limestone seeps (Steere and B. Murray, 1976; Brown and Berg, 1980). On the Landsat classification alpine areas are depicted either as partially vegetated (unit IXb) or barren (unit X).

River Flood Plains

Landforms and soils

The river flood plain terrain type includes the present-day channels and braided drainages as well as the adjacent abandoned channels and delta that indicate formerly much more extensive river systems. This terrain type covers 24.6 percent of the study area. The present-day river flood plain consists of the active channel and usually one or more terraces (figs. B-30 and B-31). An idealized section across a river channel is shown in figure B-4. Most of the major rivers within the part of the wildlife refuge being considered here have braided channels ranging in width from 1 km to 4 km. The diamond-shaped islands that are commonly present between channels are probably inundated at least sporadically in most years during the period of meltoff (usually late May to early June). Two types of islands are recognized. The first consists of unvegetated gravels and gravelly sands (or silts in the delta region) that have numerous scour pits. These areas are flooded annually and subject to intensive water and ice scouring. No soil or vegetation is recognized on these features and they are described simply as river wash. The second type consists of islands that are not spatially removed from the main channel down-cutting or position shifts. Vegetation coverage on these features varies considerably depending upon the extent and frequency of inundation. The soils consist of various thicknesses of silt, silt loam, loam and fine sandy loam over gravel and gravelly sands. In the most stable positions a thin A_1 horizon has developed and some mottling occurs in the fine sediments. The active layer normally exceeds 1 m. The soils are classified as Cryorthents. Most islands are complexes of Cryorthents and river wash.

In a few cases, where fine sandy surface sediments have been reworked into low discontinuous sand dunes, Cryopsamment soils are recognized. Thaw depths are in excess of 1 m. Sand dunes are, however, rare in the study area and are confined mostly to the deltas of the Canning and Jago Rivers. These features are small, mostly less than 1.5 m high and composed of fine sand with a significant silt component.

Beyond the confines of the braided river channel complex are a number of paired and non-paired terraces most of which are above the influence of snow-melt flooding.

The youngest of the terraces commonly retain the relict pattern of channels and islands. For the most part, soils of the islands are Cryorthents (fig. B-3) and are well drained. The overlying fine materials may be 20 cm or more thick and are commonly bedded. The coarser layers are composed of fine sands. An organic-rich surface (A) horizon may be from a few to 15 cm thick. The channel areas are poorly to very poorly drained with fibrous organic (O) horizons up to 20 cm or more thick overlying mottled gray silt and silt loam textured materials. Permafrost is encountered usually within 0.5 m. These soils are Pergelic Cryaquepts. A surface pattern consisting of 1 to 2 m diameter polygon cells is common to the better drained, island elements. Other of the terraces may lack any surface pattern and consist mostly of wet graminoid tundra while others may have weakly expressed (disjunct) polygons and strangmoor.

Outward from the river (fig. B-4) the trend in soil and ground pattern development is toward the establishment of a shallow active layer, poor drainage with Cryorthents and Fluven-like soils giving way to Pergelic and Histic Perge'ic Cryaquepts in which the surface organic horizon is composed of fibrous sedge peat and roots. Disjunct low-centered polygons and/or strangmoor mask the relict river island pattern. Soils of the riverine areas are, with few exceptions, near neutral to moderately alkaline in reaction (pH). This is true even of the more organic-rich soils on the higher terraces since they receive frequent additions of alkaline loess.

Steep bluff slopes (24-30 percent) marginal to the rivers and a narrow strip along their crests are included within the riverine area (fig. B-4). Bluffs may be undergoing active erosion or they may be fossil, in the sense that they rise above ancient river terraces. In either case they are subject to rapid natural failure by mudflow and/or solifluction. The result is commonly a complex of soils on which the solifluction lobes, which may stand 50 cm or more above the surrounding slope, exhibit over thickened (cumlic) A horizons. Wetter areas occur upslope from and behind the lobes. In either case, the soils are Pergelic Cryaquolls.

The topographic contrast associated with this bluff produces a microtopographic reversal of former low-centered polygons (see Everett, 1980b). During the course of this reversal the low, highly organic-rich centers (often Pergelic Cryaquepts of Histic Pergelic Cryaquepts) undergo oxidation. Commonly the soils are enriched with mineral materials eroded from the exposed bluff or derived from the river island complex below. The resulting soils are well drained Pergelic Cryaquolls or in some cases Pergelic Cryoborolls. The organic-rich surface horizons are underlain by variable thicknesses of oxidized sandy textured materials that thaw to depths of 1 m or more. The processes of topographic reversal are quickly attenuated inland from the bluff edge, and generally within a distance of 100 m, low-centered polygons (or some other surface pattern) are well developed. The addition of windblow fine sand usually can be recognized for distances well beyond 100 m.

Bluff crests and their soils undergo natural profile disruption by congeliturbation and by wind abrasion. By virtue of their exposed position, they are commonly snow-free during winter.

Vegetation

Vegetation associated with river systems ranges from totally barren river gravels and mud to tundra that is indistinguishable from that in non-alluvial areas. The braided channels (fig. III-10) are subject to intense disturbance during spring break-up. In addition, meandering streams and braided rivers are constantly changing their channels. The first plants to colonize river gravels include the River Beauty (Epilobium latifolium) and Arctic Wormwood (Artemisia arctica). Slightly more stable areas are often partially vegetated but may contain a wide variety of taxa (fig. B-28 and table III-2, unit IXa, Partially Vegetated Areas, River Bars). These are among the most floristically rich sites in the region.

Willows (Salix app.) are common on partially vegetated gravel bars, and may form fairly extensive thickets; however, these thickets are nowhere near as extensive as the riparian willow communities found along rivers farther west, such as on the Sagavanirktok, Kaparuk, and Colville Rivers. This is most apparent on the Landsat classification, which shows only partially vegetated areas adjacent to the larger rivers within the refuge. Examination of aerial color infrared

photography confirmed that willows are not extensive. This contrasts markedly with impressions gained from earlier maps of the region, (e.g., Viereck and Little 1972, and Selkregg, 1975, both of which are based on Spetzman's 1959 map), which show extensive high brush communities covering about 20 percent of the study area. Planimetry of the Landsat classification (table B-2) shows less than .2 percent cover of shrub tundra within the entire study area. Dense shrubs within major river drainages (table B-2) cover only .002 percent of the study area. Most of the dense shrubs are confined to upland areas. Most willow communities along the major rivers are fairly open with large components of gravel and riparian forbs. The Landsat classification does not distinguish between the river areas that are partially vegetated with tall willows and those that are partially vegetated with prostrate shrubs and/or forbs (fig. B-29). Even if we consider all the partially vegetated areas within the river flood plain terrain type to be dominated by shrub willows, the willow shrublands would total no more than 1.25 percent of the study area (see table B-2).

Dense willow communities are perhaps more common along some of the smaller drainages outside the major flood plains (fig. B-28) where the soils are somewhat more stable. In most cases, these drainages are quite narrow and unlikely to appear on the Landsat image. Smaller streams and quieter interchannel areas of the larger rivers have lush sedge and willow stands. The heights of the willows vary according to the amount of winter snow cover and also the summer temperature regime. Willows near the coast are mostly prostrate; whereas, near the southern boundary of the study area, shrubs can exceed 2 m in height.

More common features in braided drainages are the Dryas dominated river terraces (fig. B-30 and table III-2, unit IVb). These terraces are usually just above the main channels, and are especially common along the Canning River. On the Landsat scenes we used, these terraces have spectral signatures similar to that of Moist/Wet Tundra Complex (table III-2, unit IVa). The dark shade of these terraces is due to the mat of Arctic Dryads (Dryads integrifolia), and the lack of light-colored erect dead vegetation and lichens that are annually washed away by the spring floods. These terraces are important for numerous species of wildlife. Arctic ground squirrels, foxes and lemmings all are attracted to the dry sandy soils for denning sites, and grizzly bears are often seen hunting for the smaller animals in these areas. It would be good to be able to separate the dry terraces from the much more abundant but less floristically and faunistically rich Moist/Wet Sedge Tundra Complex. This may be possible on Landsat scenes taken in late summer or early autumn, when the Dryas is a red color.

Another important feature in river areas are the numerous areas of river icings (fig. III-11). These occur in braided sections of the larger rivers where the channel freezes to the bottom in most winters. They also occur downstream from perennial springs that supply a constant source of water during the winter.

Summary of the principal landcover categories, landforms and vegetation within each terrain type

Table B-6 summarizes the dominant Landsat landcover categories and the principal geobotanical features for each terrain type. The table can be used to compare regions and condenses much of the information presented in this section. The table also contains more specific information regarding the dominant plant communities within the various landcover units.

Evaluation of the Map Legend and Equivalent Units in Other Vegetation Classification Systems

Need for a Tundra Classification System

The Landsat landcover units used here were developed because there is presently not a classification system that is suitable for Landsat maps of Arctic Tundra vegetation. Previous attempts (Nadler and others, 1978; Morrisey and Ennis, 1980) at using Landsat in northern Alaska have departed from the national Landsat classification scheme developed by the USGS (table B-6) (Anderson and others, 1976). We also found it difficult to work within the confines of this scheme. The main problem with the USGS system is in the Level II categories where the system mixes community physiognomy (Shrub and Brush Tundra, Herbaceous Tundra) with site moisture (Wet Tundra) at the same level, and compunds the confusion with the class Mixed Tundra.

Within Alaska, the most widely accepted classification system is that of Viereck and Dyrness (1980) (table B-6). The problems in applying this system to Landsat classification begin at Level I where the term tundra occurs at the same level with Shrublands Herbaceous vegetation, and Aquatic vegetation, all of which could conceivably contain common tundra types. At Level II plant physiognomy (herbaceous, tussock, tall shrub, low shrub) is mixed with site ecology (freshwater, saltwater). Level III uses several criteria including plant cover (open forest vs. closed forest), site moisture (wet sedge grass vs. mesic sedge grass), altitude (low elevation herbaceous tundra vs. alpine herbaceous tundra), plant taxa (willow vs. birch and ericaceous shrubs and site characters (estuarine vs. intertidal). It is difficult to see within this system a consistent method of naming the wide variety of vegetation types that can occur within the tundra.

We see a real need to develop legends that are compatible at large and small scales, the ultimate goal is a comprehensive mapping system that can be used for both the broad picture and for detailed site-specific planning.

In the past 10 years, we have mapped numerous areas of the Alaskan Arctic Coastal Plain and have experimented with various map legends, primarily at the large scale of 1:6000 (Walker, 1977; Webber and others, 1979, unpublished manuscript; Walker and others, 1980; Sohio Petroleum Co., 1981). We have developed a system of mapping that we feel can accurately describe any Alaskan tundra landscape at large scales. We are now in the process of writing a description of the systems (Walker and others, in prep.). The Landsat landcover classification presented here (plate 1) is compatible with the large-scale mapping system (see Methods, Map Legend). We see the nomenclature system as still in a state of evolution, but several features of the current system are worth emphasizing :

1. The system is compatible for both large- and small-scale mapping.

2. A site moisture term followed by the dominant plant growth-forms. At large scales the dominant plant taxa are added to form the plant community name.

3. It has a consistent method of naming vegetation complexes, and this can be done at any scale.

For large-scale geobotanical master maps (Everett and others, 1978, Walker and others, 1980), where additional characteristics of the landscape are also being mapped, this system has the major advantage that it contains only vegetation information, and is independent of soil, landform, altitude, etc. Purists may want to separate the site moisture descriptor since this is a character of the site, and this can be easily done since it consistently appears in the same part of the title. For example, in the map legend for the ANWR study site (plate 1), Shrub Tundra does not have a site moisture modifier since this unit commonly occurs in both moist and wet sites. The reader may also note on the map that Aquatic Tundra does not have a growth-form in the landcover unit name. This could be proper in some areas where aquatic communities, consisting of a wide variety of growth-forms, such as pond lilies, sedges, grasses and even shrubs, may not be separable on the Landsat imagery. However, in the ANWR study area most aquatic communities are dominated by either sedges or the grass Arctophila fulva; so the term "graminoid" should be used, and the corrected landcover category should read "Aquatic Graminoid Tundra."

Equivalents in Other Classification **Systems**

Currently, there are several classification schemes that are being applied to Alaskan tundra. Probably no one of these is going to gain universal acceptance. There is consequently a need to show equivalent units between the major classification systems. Equivalents for six systems are shown in table B-7.

International Systems

Two international systems were looked at (Fosberg, 1967 and UNESCO, 1973). Only the UNESCO equivalents are shown in table B-7. These systems were found to be either too broad for application in Alaska (the case with the UNESCO system) or their terminology is too difficult to interpret for mapping purposes. For example, the Fosberg term for a typical willow shrubland would be a mesophyltous deciduous orthophyll shrub. One positive aspect of both systems is that they consistently apply plant characteristics (as opposed to site or ecological characteristics) in their nomenclature systems.

Other Landsat Landcover Classifications

The USGS national Landsat classification systems (Anderson and others, 1976) has already been discussed. Two other Landsat systems have been used in northern Alaska. The first was developed by Nodler and LaPerriere for maps of ANWR (Nodler and LaPerriere, 1979) and vegetation in northwestern Alaska (Nodler and others, 1978). The second was that used by Morrisey and Ennis (1980) to map the vegetation of the NPRA. Table B-7 shows equivalents for the Anderson and others system and the Nodler and LaPerriere map of ANWR.

Wetland systems

Two methods of classifying wetlands are currently being used in northern Alaska. The National Wetland Inventory (NWI) (Cowardin and others, 1977) is being used nationwide and has been used for several 1:63,360 maps in northern Alaska. The other system (Bergman and others, 1977) was developed by the USFWS specifically for waterfowl habitat at Point Storkerson. The system has also been

used in the Teshekpuk Lake vicinity (Dirkson and others, 1981). Both systems are only applicable for the wetter landcover types. Equivalents for both systems are shown in table B-7.

Evaluation of the Landsat Survey Approach

The study of the Arctic National Wildlife Refuge provided an ideal application of Landsat mapping technology. The area is vast and remote with poor overland access. Detailed landcover maps were required within a very restricted time frame. Landsat experiences at Prudhoe Bay and the National Petroleum Reserve in Alaska (NPRA) have shown that excellent landcover maps can be produced for the Arctic Coastal Plan because of the generally high correlation between site moisture and the Landsat spectral signatures (Morrisey and Ennis, 1980; Acevedo and Walker, in prep.). The lack of trees and the flat landscape with no shadows are other very desirable aspects of the terrain for Landsat classification. This mapping experience in ANWR shows that Landsat is also suitable in the foothills. Deep shadows are not common and the vegetation is mostly tussocks and low shrubs. There is one important difference that separates the vegetation of the wet coastal plain from that in the foothills. On the coastal plain, most cover types are distinguished on the basis of moisture regime. The less wet or moist types generally have high reflectivity due to less standing water and more cover of live plants and, more importantly, erect live dead sedge leaves. On the driest sites there is often an abundance of white crutose lichens and/or light-colored gravels. Characteristics of the moisture gradient are most apparent in the visible Band 4. This is in contrast to the tussock tundras of the foothills where the amount of shrubs in the plant canopy is the main distinguishing feature between vegetation types. Deciduous shrubs have high reflectivity in the infrared bands, hence, it is possible to separate shrub-poor and shrub-rich tundras mainly on the basis of their reflectivity in Band 2.

Another important feature of foothills terrain that became apparent from the Landsat map is the widespread occurrence of frost scar tundra. In areas underlain by neutral or alkaline materials, frost activity creates two distinct tundra types, one associated with alkaline frost-scar tundra (unit Vb), and one associated with less frost-active acidic areas (unit VI). Over 30 percent of the foothills terrain type is covered by unit V (table B-2). On the basis of our 1981 survey, by far the largest part of this is unit Vb, the frost-scar tundra.

The color Landsat map at 1:250,000 is a substantial improvement over earlier maps and can be a basis for planning habitat studies. Additional Landsat products at 1:63,360 or 1:24,000 can be easily made. It should be emphasized, however, that these cannot replace master maps of the kind used at Prudhoe Bay (Walker and others, 1980). Master maps, depicting diverse site-specific information, are best produced with conventional underflight photography at a scale of 1:6000 and a thorough ground review. Information incorporated in master maps include, soils, landforms, vegetation, slope and microrelief, and most of this information cannot be obtained from Landsat data.

The division of the region into terrain types proved to be a useful framework for this study and should be equally useful in other regions. This approach can be especially good for interpreting some areas with spectral confusion between landcover types. For example, on the river flood plains there is spectral confusion

between the Moist/Wet Sedge Tundra Complex and Dry Prostrate Shrub, Forb Tundra (Dryas river terraces). However, in the foothills terrain type, this confusion does not exist because the latter landcover type does not occur.

One of the most useful features of the Landsat approach is the ease of producing planimetry data. The digital nature of Landsat data allows for quick acreage summaries that would otherwise be difficult to obtain.

A criticism that has been leveled at Landsat maps is the difficulty in defining discrete units. For this reason, many land managers prefer pologon maps. These can be easily made from the Landsat product (plate 2), but often with a loss of information and also some loss of spatial truth. We produced plate 2 from an earlier version of the Landsat map so that users could have a polygon map. After we made plate 2, a better Landsat map was made (plate 1) by generalizing the data for cartographic display (see Methods, Landsat Classification). Comparison of plates 1 and 2 show that in many ways, the Landsat map is the superior product. Most tiny map units have been eliminated, so that the map is now virtually a polygon map except that it lacks black lines around the distinct units.

Finally, it should be emphasized that this classification is a preliminary one. It should be used for planning purposes during the current urgent requirement to produce an environmental impact statement since it provides the best regional coverage and resolution available at this time. However, the map does require field checking, and several problem landcover categories need to be examined in detail. A final map should be produced following appropriate field checking.

CONCLUSIONS

The production of the Landsat map of the ANWR study area has given us a picture of a portion of the Arctic Coastal Plain that is unlike that which has been studied extensively, such as at Barrow and Prudhoe Bay. It is a more hilly landscape that has been dissected by numerous braided flood plains that flow directly north from the Brooks Range. Much of the area consists of true foothills that rise to meet the peaks of the Romanzof and Sadlerochit Mountains. Only a small portion of the area has flat thaw-lake plains similar to those that cover most of the coastal plain west of the Canning River.

This report contains descriptions of the major landforms, soils, and vegetation in each of five major terrain types; flat thaw-lake plains, hilly coastal plain, foothills, alpine terrain, and river flood plains. Results of the planimetric analysis emphasize several important factors regarding the study area.

1. Thaw-lake plains cover only about 3 percent of the study area. Units where wet tundra habitats are likely to occur (Landcover units I, II, III, and IV) cover less than 40 percent of the region. These areas are seen as particularly sensitive to surface exploration and valuable as waterfowl habitat.

2. River flood plains and braided river deltas cover nearly 25 percent of the study area. This has important implications for the many wildlife species that utilize habitat associated with these areas.

3. Moist sedge, prostrate shrub, tundra and tussock sedge, dwarf shrub, tundra (units IV, V, and VI) are the dominant landcover types, covering 55 percent of the region. Frost scar tundra covers large areas of the uplands. However,

there is currently spectral confusion between frost scar tundra and other landcover categories. It is hoped that this problem can be eliminated by reclustering the data and/or by use of digital terrain elevation (DEM) data.

4. Riparian shrub communities are not nearly as extensive as depicted on previous maps of the region. Only 0.2 percent of the area has dense shrubs. Open shrub communities along rivers account for no more than 1.25 percent of the area.

The Landsat approach is seen as perfectly suited for this mapping task. It has yielded a very good preliminary map, that is spatially highly accurate. It has produced the final product from beginning of the project to the publishable map in eight months. This would be virtually impossible with conventional photo interpretation methods. The use of high resolution CIR photography and our considerable experience with Landsat in other parts of northern Alaska have allowed us to make this map with a minimum amount of time in the field. It should be reemphasized, however, that adequate ground truth is the key to producing good Landsat maps. The Landsat map presented in this report still needs to be field checked and should be considered a preliminary map at this time.

The results of this study can be used as a framework for more detailed habitat studies. The planimetric data provided for the terrain types and for the townships should be useful for evaluating the site characteristic of relatively small areas. The Landsat classification can also be easily expanded to larger scales for more detailed analysis of specific sites.

We recommend using the results of this study as a framework to select areas within each of the major terrain types for detailed studies including, master maps and investigations of the soils, vegetation, geomorphic processes and wildlife use. The four areas we visited in 1981 would be good study sites, and we recommend the addition of an alpine site near Sadlerochit Spring and a flat thaw-lake plain site southwest of Barter Island. Such studies would help in evaluating the overall reliability of the Landsat map and would aid immensely in the proper evaluation of the impact of seismic operations within the wildlife refuge.

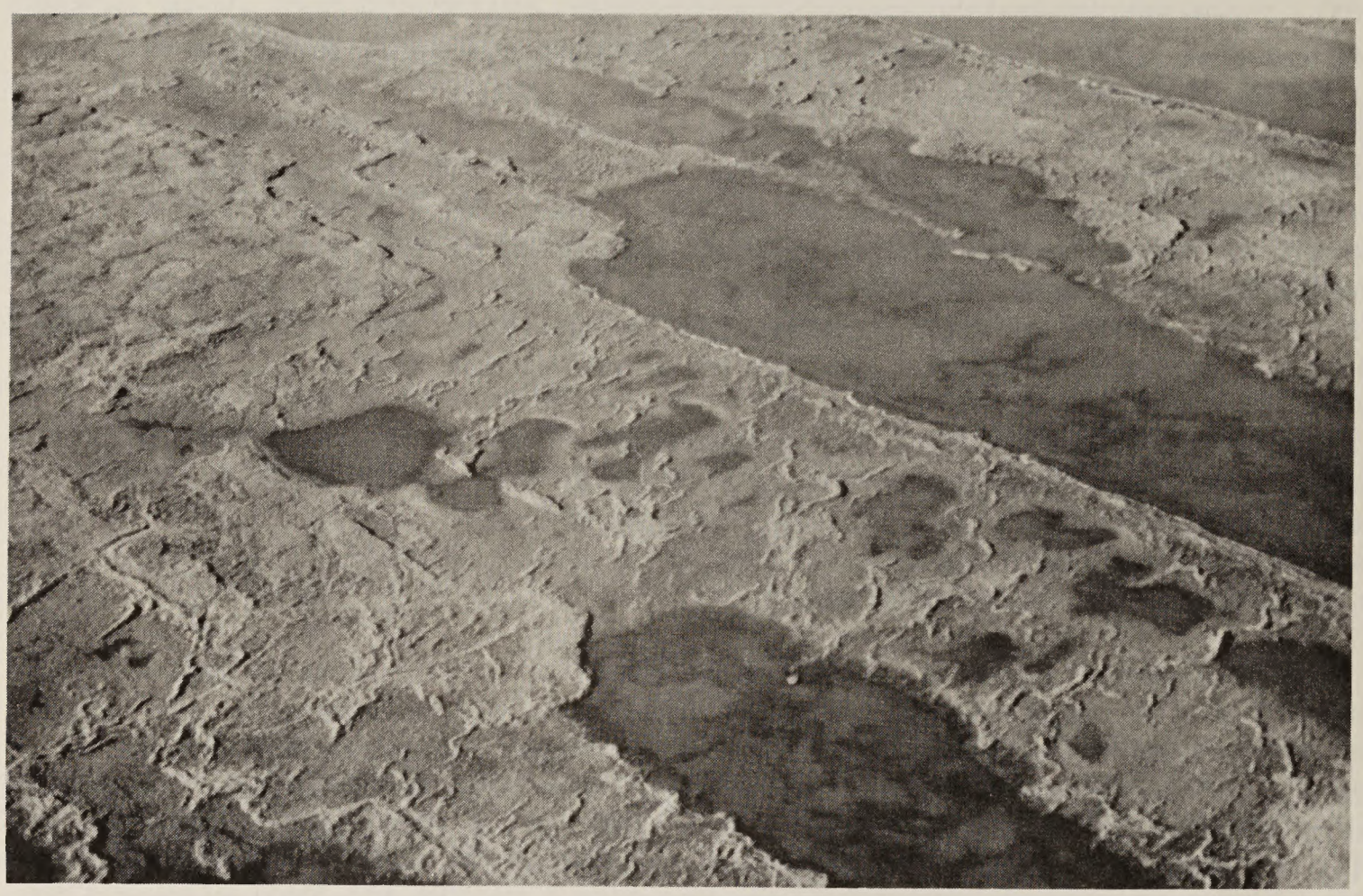


Figure B-17.--Unit III, Wet Sedge Tundra. The areas between lakes and ponds are mostly wet sedge tundra. This area is a partially drained lake basin with disjunct rims and strang features. The interpond areas contain about 20 percent moist tundra on the strangs and higher microsites. Photograph by D. A. Walker, Institute of Arctic and Alpine Research, University of Colorado.

Figure B-18.--Unit IVa, Moist/Wet Sedge Complex. This example shows about equal parts wet and moist tundra. Photograph by D. A. Walker, Institute of Arctic and Alpine Research, University of Colorado.

Figure B-19.--Ground view of Moist/Wet Sedge Tundra Complex. The relatively well-drained area in the foreground has a diverse flora with sedges, prostrate willows, herbs, and lichens, whereas the wetter areas (darker patches with cottongrass) have mainly just sedges and moss. Photograph by D. A. Walker, Institute of Arctic and Alpine Research, University of Colorado.

Figure B-20.--Unit IIb, Aquatic Tundra. The circular cones of vegetation are mainly aquatic sedge (Carex aquatilis). The darker interclone areas are pendant grass (Arctophila fulva). Photograph by D. A. Walker, Institute of Arctic and Alpine Research, University of Colorado.

Figure B-21.--Unit IIId, Wet Sedge Tundra (saline facies). This area, in the delta of the Katakturuk River, is dominated by Hoppner sedge (Carex subsoatgacca) and creeping alkali grass (Puccinellia phryganodes). Soils are saline (Halic Histic Pergelic Cryaquepts). Photograph by D. A. Walker, Institute of Arctic and Alpine Research, University of Colorado.

Figure B-22.--Unit Vb, Moist Sedge/Barren Tundra Complex (Frost-Scar Tundra). This is a typical frost-scar area on a gentle slope. Note the lack of cottongrass tussocks and dwarf shrubs. The vegetation between frost-scars consists mainly of Bigelow's sedge (Carex bigelowii), arctic avens (Dryas integrifolia), wide-leafed Arctagrostis (Arctagrostis latifolia), the moss Toment hyphum nitens and numerous fruticose lichens. Photograph by D. A. Walker, Institute of Arctic and Alpine Research, University of Colorado.

Figure B-23.--Unit VIa, Moist Tussock Sedge, Dwarf Shrub Tundra on foothills south of Camden Bay. The lighter colored upland surfaces are due to a spectacular floral display of cottongrass. The darker colored drainages have Moist Sedge-Prostrate Shrub communities. Photograph by D. A. Walker, Institute of Arctic and Alpine Research, University of Colorado.

Figure B-24.--Cottongrass tussocks in Unit VIA. This unit occurs on acidic soils. The main shrubs are diamond-leafed willow (Salix planifolia ssp, pulchra), dwarf birch (Betula nana ssp. exilis), bog blueberry (Vaccinium uliginosum), and mountain cranberry (V. vitis-idaca). Photograph by D. A. Walker, Institute of Arctic and Alpine Research, University of Colorado.

Figure B-25.--Unit VIIa, Moist Dwarf Shrub, Tussock Sedge Tundra. The dwarf shrubs are dominant in this unit, which tends to occur on the least disturbed upland surfaces. Photograph by D. A. Walker, Institute of Arctic and Alpine Research, University of Colorado.

Figure B-26.--Unit VIIb, Moist Tussock Sedge, Dwarf Shrub/Wet Dwarf Shrub Tundra Complex (water-track) complex). Drainage channels are dominated by dwarf shrubs, mainly diamond-leafed willow (Salix planifolia ssp. pulchra) and dwarf birch (Betula nana ssp. exilis). Photograph by D. A. Walker, Institute of Arctic and Alpine Research, University of Colorado.

Figure B-27.--Unit VIII, Shrub Tundra. This site is on a steep south-facing slope of a rocky ridge near the Jago River. Photograph by D. A. Walker, Institute of Arctic and Alpine Research, University of Colorado.

Figure B-28.--Meandering tundra stream. Note the willows and numerous oxbous that are valuable wildlife habitat. Photograph by D. A. Walker, Institute of Arctic and Alpine Research, University of Colorado.

Figure B-29.--Partially vegetated river bar on the Katakturuk River. The main flowering plant is pale paintbrush (Castilleja caudata). Photograph by D. A. Walker, Institute of Arctic and Alpine Research, University of Colorado.

Figure B-30.--Unit IVb, Dry Prostrate Shrub, Forb Tundra (Dryas river terrace). This unit typically occurs on reticulate patterned river terraces with small soil polygons 20 to 40 cm in diameter. Barren frost-disturbed areas are common. The primary taxa here are arctic avens (Dryas integrifolia), blackish oxytrope (Oxytropis nigrescens), alpine milk-vetch (Astragalus alpinus) and common cottongrass (Eriophorum triste). Photograph by D. A. Walker, Institute of Arctic and Alpine Research, University of Colorado.

Figure B-31.--A small stream bordered by lush sedge communities, in the foothills south of Camden Bay. Photograph by D. A. Walker, Institute of Arctic and Alpine Research, University of Colorado.

Table B-2.--Planimetry data for the Arctic National Wildlife Refuge study area

Landcover unit	Acres of study area	Hectares of study area	Percentage of terrain type	Percentage of study area
		A. Flat Thaw-Lake Plains		
I	9,771	3,954.2	19.36	0.60
II	4,227	1,710.6	8.37	0.26
III	23,282	9,422.0	46.13	1.42
IV	6,462	2,615.1	12.80	0.39
V	3,723	1,506.7	7.38	0.23
VI	413	167.1	0.82	0.03
VII	38	15.4	0.07	0.002
VIII	50	20.2	0.10	0.003
IX	317	128.3	0.63	0.02
X	674	272.8	1.33	0.04
XI	936	378.8	1.85	0.06
XII	577	233.5	1.14	0.04
Total	50,470	20,424.7	99.98	3.095
		B. Hilly Coastal Plains		
I	6,634	2,684.7	1.80	0.40
II	4,260	1,724.0	1.16	0.26
III	83,484	33,785.1	22.69	5.09
IV	123,476	49,969.5	33.55	7.53
V	136,846	55,380.2	37.19	8.34
VI	7,158	2,896.8	1.95	0.44
VII	0	0.0	0.00	0.00
VIII	0	0.0	0.00	0.00
IX	3,086	1,248.9	0.84	0.19
X	2,461	995.9	0.67	0.15
XI	300	121.4	0.08	0.02
XII	283	114.5	0.08	0.02
Total	367,988	148,921.0	100.01	22.44

Table B-2.--Planimetry data for the Arctic National Wildlife Refuge study area--Continued

Landcover unit	Acres of study area	Hectares of study area	Percentage of terrain type	Percentage of study area
		C. Foothills		
I	1,816	734.9	0.25	0.11
II	761	308.0	0.10	0.05
III	9,969	4,034.4	1.36	0.61
IV	39,108	15,826.6	5.33	2.38
V	224.545	90,871.1	30.61	13.69
VI	394,701	159,731.6	53.81	24.06
VII	50.963	20,624.2	6.95	3.11
VIII	3,091	1,250.9	0.42	0.19
IX	2,653	1,073.6	0.36	0.16
X	5,571	2,254.5	0.76	0.34
XI	328	132.7	0.05	0.02
XII	41	16.6	0.01	0.003
Total	733,547	296,859.1	100.01	44.723
		D. Mountainous Terrain (Alpine)		
I	80	32.4	9.54	0.005
II	101	40.9	12.04	0.006
III	50	20.2	5.96	0.003
IV	23	9.3	2.74	0.001
V	63	25.5	7.51	0.004
VI	32	13.0	3.81	0.002
VII	18	7.3	2.15	0.001
VIII	2	0.8	0.24	0.0001
IX	302	122.2	36.00	0.002
X	147	59.5	17.52	0.01
XI	21	8.5	2.50	0.001
XII	0	0.0	0.00	0.00
Total	839	339.6	100.01	0.035

Table B-2.--Planimetry data for the Arctic National Wildlife Refuge study area--Continued

Landcover unit	Acres of study area	Hectares of study area	Percentage of terrain type	Percentage of study area
		E. River Flood Plains		
I	17,645	7,140.8	4.37	1.08
II	7,063	2,858.3	1.75	0.43
III	138,575	56,079.9	34.30	8.45
IV	100,217	40,556.8	24.81	6.11
V	69,055	27,945.9	17.09	4.21
VI	12,826	5,190.6	3.18	0.78
VII	648	262.2	0.16	0.04
VIII	34	13.8	0.01	0.002
IX	20,438	8,271.1	5.06	1.25
X	17,806	7,205.9	4.41	1.09
XI	15,985	6,469.0	3.96	0.97
XII	3,694	1,495.0	0.91	0.23
Total	403,986	163,489.3	100.01	24.642
Grand total	1,556,830	630,033.7		

Table B-3.--Acreage summaries of the vegetation of the Arctic coastal plain portion of the Arctic National Wildlife Refuge

Unit	Landcover category	Acres	Percentage of study area
I	Water*	101,355	6.18
II	Pond Complex or Aquatic Tundra	16,964	1.03
III	Wet Sedge Tundra	260,057	15.85
IV	Moist/Wet Sedge Tundra Complex or Dry Prostrate Shrub, Forb Tundra	270,565	16.49
V	Moist Sedge, Prostrate Shrub Tundra or Moist Sedge/Barren Tundra Complex	434,512	26.48
VI	Moist Tussock Sedge, Dwarf Shrub Tundra	414,550	25.27
VII	Moist Dwarf Shrub, Tussock Sedge Tundra or Moist Tussock Sedge, Dwarf Shrub/Wet Dwarf Shrub Tundra Complex	51,148	3.12
VIII	Shrub Tundra	3.142	0.19
IX	Partially Vegetated Areas	27,678	1.69
X	Barren Gravels or Rock	27,642	1.68
XI	Barren Mud or Wet Gravels	28,402	1.67
XII	Ice	4,612	0.28
		1,640,626	100.00

*The water category includes ocean within the study area boundary.

Table B-4.--Temperature and precipitation data for Barter Island, Alaska
(From Searby, 1968; Brower and others, 1977)

(Latitude: 70°08' N. Longitude: 143°35' W. Elevation: 12 m)

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
						Temperature (°C)							
Max.	-23.2	-25.2	-22.1	-13.0	-3.4	3.9	8.6	7.3	2.2	-5.2	-14.2	-19.8	-8.7
Min.	-30.9	-32.2	-30.1	-21.6	-9.2	-1.5	1.7	1.5	-2.1	-11.3	-21.2	-27.3	-15.3
Mean	-27.1	-28.7	-26.1	-17.3	-6.3	1.2	5.2	4.4	0.1	-8.2	-17.7	-23.6	-12.0
												Highest	25.6°
												Lowest	-50.6°
						Wind (km hr^{-1}), Principal Direction							
	23.9W	22.3W	21.7W	19.0E	19.5E	18.0E	16.9E	18.4E	21.0E	22.8E	24.3E	22.6W	24.1E
											Highest	149 km hr^{-1}	W
						Precipitation (mm)							
	10.2	8.9	5.1	4.3	6.4	13.0	22.4	26.7	23.9	21.3	10.2	7.4	159.5
											Mean annual snowfall		115 cm

Table B-5.--Acreage summaries: Vegetation types in each township in the Arctic coastal plain portion of the Arctic National Wildlife Refuge

Township	Unit I	Unit II	Unit III	Unit IV	Unit V	Unit VI	Unit VII	Unit VIII	Unit IX	Unit X	Unit XI	Unit XII	Totals
T3NR34E	8	11	99	398	1822	16015	3215	233	364	186	1	0	22352
R35E	0	0	16	219	848	16704	4097	78	72	39	0	0	22072
R36E	0	1	173	1080	2515	17381	869	1	275	49	0	0	22345
R37E	57	7	206	395	1808	15633	401	0	0	7	0	0	18514
R38E	0	0	214	536	306	634	26	0	0	0	0	0	1716
T4NR31E	521	502	778	2087	4419	10823	444	22	1180	1015	63	311	22163
R32E	2	14	143	648	2814	17068	1099	19	347	184	49	0	22389
R33E	0	0	124	729	1887	18137	849	2	12	49	0	0	21783
R34E	32	42	1272	3506	6234	10021	95	0	756	199	19	0	22177
R35E	2	2	1856	4896	4505	9532	99	0	554	465	73	1	21986
R36E	4	11	628	2541	5051	13291	81	3	345	208	26	0	22189
R37E	0	3	118	658	6273	14635	228	0	12	49	0	0	21976
R38E	0	3	2087	3926	4618	4446	27	0	121	46	1	0	15274
R39E	0	0	101	191	42	0	0	0	22	2	0	0	359
T5NR23E	302	0	622	282	6848	2717	235	64	0	49	1970	0	13089
R24E	164	0	140	24	7346	14316	453	215	0	0	0	0	22658
R25E	259	0	741	38	9633	11464	179	123	0	16	6	6	22463
R26E	33	12	387	1634	6840	11976	1595	24	2	683	0	0	23185
R27E	0	0	1147	2404	5468	7590	5199	152	2	1258	0	1	23220
R28E	0	0	72	1125	4315	8107	8423	840	0	116	0	0	23000
R29E	0	0	24	572	2600	13685	4812	79	235	524	0	7	22537
R30E	0	0	80	764	1369	19085	920	0	171	75	0	0	22464
R31E	27	84	1073	4552	6660	7834	31	0	1393	424	104	37	22220
R32E	57	22	1813	8651	5606	4318	7	0	554	837	276	269	22409
R33E	89	40	1402	4338	8604	6949	7	0	468	175	78	0	22149
R34E	374	175	3238	6741	8271	2902	0	0	258	213	128	3	22302
R35E	231	142	3136	6700	9608	483	0	0	809	881	158	3	22151
R36E	199	93	1817	4825	13663	563	0	0	427	645	20	127	22379
R37E	14	30	2439	8246	11194	293	0	0	103	23	0	0	22343
R38E	0	9	7728	9452	3838	50	0	0	165	78	1	1	21322
R39E	0	3	7172	4372	457	0	0	0	185	0	7	0	12197
R40E	13	31	1194	541	4	0	0	0	80	0	30	0	1894

Table B-5.--Acreage summaries: Vegetation types in each township in the Arctic coastal plain portion of the Arctic National Wildlife Refuge--Continued

Township	Unit I	Unit II	Unit III	Unit IV	Unit V	Unit VI	Unit VII	Unit VIII	Unit IX	Unit X	Unit XI	Unit XII	Totals
T6NR23E	635	0	1867	935	7198	4159	83	34	0	48	897	0	15856
R24E	27	0	89	12	5691	15200	789	582	0	6	0	0	22395
R25E	0	1	50	238	7107	12200	2994	391	0	184	1	0	23166
R26E	0	0	342	987	8542	10890	1726	88	0	589	0	0	23164
R27E	0	0	495	1051	7500	10494	2716	102	8	650	1	0	23017
R28E	19	4	504	2827	8304	7903	2499	52	21	874	1	2	23011
R29E	0	0	389	1497	7513	11970	1200	50	1	432	0	1	23052
R30E	64	8	60	463	4842	16812	19	0	38	182	0	0	22487
R31E	108	168	545	2050	8006	10315	8	0	780	184	141	3	22309
R32E	151	23	3741	9771	5998	1183	0	0	794	387	466	3	22519
R33E	6	14	677	4032	14583	2341	0	0	211	243	29	1	22137
R34E	674	369	6667	7474	6609	212	0	0	79	228	21	11	22342
R35E	123	179	4141	7771	8357	22	0	0	483	1016	165	29	22287
R36E	384	286	4953	5410	10915	3	0	0	149	254	2	21	22378
R37E	406	251	5710	4845	10345	0	0	0	344	428	1	29	22360
R38E	16	19	6148	7136	7935	0	0	0	537	398	0	65	22256
R39E	2153	215	11008	5514	2743	1	0	0	393	65	46	0	22139
R40E	4216	359	2357	221	11	0	0	0	83	31	134	0	7411
T7NR23E	245	28	3372	1297	248	44	4	0	484	486	930	777	7915
R24E	364	181	5988	2256	4455	2676	609	132	1361	548	2605	1950	23126
R25E	143	141	3118	2939	8264	5267	1872	297	88	474	271	1	22873
R26E	18	75	6122	4194	6442	3501	1098	109	46	1151	9	75	22840
R27E	349	180	1853	2100	11016	6273	868	172	0	18	0	0	22828
R28E	937	29	6232	4026	6222	2085	278	29	68	1093	68	2	21071
R29E	3605	94	1984	2212	7701	2827	445	53	66	425	344	111	19867
R30E	917	22	98	1443	9015	5300	20	0	157	215	28	2	17217
R31E	117	109	646	3780	10451	6187	1	0	553	77	199	0	22118
R32E	296	63	7559	8759	3671	322	0	0	887	322	527	0	22406
R33E	274	278	4412	9912	5982	61	0	0	450	397	185	0	21951
R34E	542	355	5241	9747	6051	240	0	0	11	13	0	2	22202
R35E	927	695	6819	7718	3933	10	0	0	477	1068	283	125	22055
R36E	244	176	1682	5045	14605	67	0	0	170	127	4	17	22137
R37E	525	461	5791	3965	10440	47	0	0	687	224	18	10	22167
R38E	1730	181	2777	3469	12763	0	0	0	391	264	48	34	21657
R39E	3405	107	1633	1370	602	0	0	0	236	113	132	9	7607

Table B-5.-- Acreage summaries: Vegetation types in each township in the Arctic coastal plain portion of the Arctic National Wildlife Refuge--Continued

Township	Unit I	Unit II	Unit III	Unit IV	Unit V	Unit VI	Unit VII	Unit VIII	Unit IX	Unit X	Unit XI	Unit XII	Totals
T8NR24E	507	300	11020	377	2	0	0	0	785	370	2319	44	15724
R25E	894	520	14696	590	134	2	0	0	1242	536	4296	1	22910
R26E	6340	1849	9966	1454	500	50	1	6	275	450	1846	35	22773
R27E	8646	633	3359	838	897	86	3	3	17	38	411	560	15491
R28E	2736	214	516	98	129	14	0	1	2	10	112	4	3838
R30E	109	6	20	65	28	1	0	0	7	0	0	0	235
R31E	3561	147	1006	3553	1839	198	0	0	159	12	119	0	10593
R32E	5940	342	5832	2809	626	0	0	0	1455	390	2886	0	20280
R33E	3712	731	8146	5670	1698	18	0	0	823	304	1050	0	22152
R34E	2044	743	5451	8755	5246	57	0	0	119	31	22	2	22469
R35E	347	279	10037	7465	2474	1	0	0	616	680	407	8	22314
R36E	1383	1258	7181	5376	6434	0	0	0	468	352	139	12	22602
R37E	3341	355	6838	4473	2445	0	0	0	159	206	192	3	18013
R38E	447	52	1253	1177	1914	0	0	0	200	162	52	29	5286
T9NR24E	2399	463	7033	25	0	0	0	0	31	320	683	0	10954
R25E	5395	1359	6793	1149	73	1	0	0	69	488	814	6	16148
R26E	1571	12	122	1	0	0	0	0	0	11	39	0	1755
R32E	2355	4	0	0	0	0	0	0	28	141	127	0	2655
R33E	11679	74	852	480	36	1	0	0	150	279	168	0	13718
R34E	6802	658	2364	184	49	0	0	0	684	516	2617	1	13876
R35E	6723	553	1772	1036	135	0	0	0	274	114	186	1	10795
R36E	2094	0	0	0	0	0	0	0	0	30	21	0	2146

Table B-6.--Four-level hierarchy for mapping tundra regions

	LEVEL			
	1.	2.	3.	4.
Application	Very small scale maps	Small-scale, very general, Landsat-level maps	Small-scale, more detailed, Landsat--level maps	Large-scale maps with detailed ground reference data
Scales	1:2,500,000 or smaller	1:1,500,000	1:24,000-1:500,000	1:400-1:24,000
Nomenclature	1. Physiognomic descriptors only	1. Physignomic descriptors, 2. Site moisture	1. Physiognomic descriptors, 2. Site moisture, 3. Dominant plant growth forms	1. Physiognomic descriptors, 2. Site moisture, 3. Dominant plant growth forms, 4. Species composition
Examples	1. Tundra, 2. Barrens 3. Dry Tundra	1. Wet Tundra 2. Moist Tundra 3. Dry Tundra	1. Wet sedge Tundra, 2. Moist Sedge, Prostrate Shrub Tundra, 3. Moist/Wet Sedge Tundra, Complex, 4. Dry Prostrate Shrub Tundra/Barren Complex	1. WET *Carex aquatilis*, *Drepanocladus brevifolius* SEDGE TUNDRA 2. MOIST *Eriophorum triste*, *Dryas integrifolia*, *Salix arctica*, *Tomenthypnum nitens*, *Thamnolia subliformis* SEDGE, PROSTRATE SHRUB TUNDRA
Notes			Map categories can include vegetation complexes, or combinations of land-cover types	Map catagories can include vegetation complexes which require complete descriptions for each part of the complex (see example)

Table B-7.--Appropriate equivalent units in several systems of landcover, wetland, and vegetation classifications used in northern Alaska--Continued

	1981 ANWR Landsat classification	Other Remote Sensor Land Cover Classifications: National USGS classification system Anderson and others (1976) Level II	Other Remote Sensor Land Cover Classifications: ANWR Landsat classification Nodler and LaPerriere (1977)	Wetland Classifications: Pt. Storkerson wetlands Bergman and others (1977)	Wetland Classifications: National Wetland Inventory Cowardin and others (1979)	Vegetation Classifications: Alaska Viereck and others (Unpubl. Manu. 1981) Level IV where possible	Vegetation Classifications: International UNESCO (1973)
IV.	b. Dry Prostrate Shrub, Forb Tundra (Dryas river terraces)	82 Herbaceous Tundra	VIII. Dryas Terrace Community	None	Upland, PSS1A PSS1B	2.C.(1)c. Dryas herb tundra 2.C.(1)h. Prostrate shrubs and herbs on flood plains	IV.8.3b. Cold decidous creeping or matted thicket
V.	a. Moist Sedge, Prostrate Shrub Tundra	82 Herbaceous Tundra	VIII.A) Upland Sedge Meadow	None	Upland, PSS1B / EM5	3.C.(1)g. Sedge-willow tundra or 3.C.(1)i. Sedge-dryas tundra	V.C.8b. Graminoid sod-form tundra
V.	b. Moist Sedge/Barren Tundra Complex (frost-scar tundra)	82 Herbaceous Tundra	XI. Hummocky frost-heaved ground	None	Upland, PSS1B / EM5	Complex of 3.C.(1)g. or 3.C.(1)i. and barrens	V.C.8b. Graminoid sod-form tundra
VI.	a. Moist Tussock Sedge, Dwarf Shrub Tundra (alkaline facies)	82 Herbaceous Tundra	IX.B) Tussock Meadow	None	Upland, PSS1B / EM5	3.C.(2)d. Sedge tussock-mixed shrub	V.C.8a. Graminoid bunch-form tundra
VI.	b. Moist Tussock Sedge, Dwarf Shrub Tundra (alkaline facies)	82 Herbaceous Tundra	IV.B) Tussock Meadow	None	Upland, PSS1B / EM5	3.C.(2)d. Sedge tussock-mixed shrub; 3.C.(2)d. Sedge tussock-willow	V.C.8a. Graminoid bunch-form tundra
VII.	a. Moist Dwarf Shrub, Tussock Sedge Tundra (upland dwarf shrub, tussock sedge tundra)	82 Shrub Tundra	IV.B) Tussock Meadow	None	Upland, PSS1B / EM5	V.C.(2)d Sedge tussock-mixed shrub	V.C.8z Graminoid bunch-form tundra
VII.	b. Moist Dwarf Shrub, Tussock Sedge Tundra (dwarf birch tundra)	82 Shrub Tundra	IV.B) Tussock Meadow	None	Upland, PSS1B / EM5	2.B.(3)h. Dwarf birch-ericaceous shrub-sphagnum bog	IV.E. Mossy bog formations with dwarf shrub IV.D.1a. Caespitose dwarf shrub mossy tundra

Table B-7.--Appropriate equivalent units in several systems of landcover, wetland, and vegetation classifications used in northern Alaska

	1981 ANWR Landsat classification	Other Remote Sensor Land Cover Classifications		Wetland Classifications		Vegetation Classifications	
		National USGS classification system Anderson and others (1976) Level II	ANWR Landsat classification Nodler and LaPerriere (1977)	Pt. Storkerson wetlands Bergman and others (1977)	National Wetland Inventory Cowardin and others (1979)	Alaska Viereck and others (unpubl. Manu. 1981) Level IV where possible	International UNESCO (1973)
I.	Water	50 Water	II. Water, Shadows	V. Deep Open	M1OWL, E1OWL, POWH, L1OWH, R1OWH, R2OWH R3OWH	None	None
	a. Pond/Sedge Tundra	84 Wet Tundra	II. Water, Shadows VI.A) Shallow Water Communities	VI. Basin-Complex	PEM5H / OW	None	None
	b. Aquatic Tundra	84 Wet Tundra	VI.A) Shallow Water	IV. Deep Arctophila or III. Shallow Arctophila or II. Shallow Carex	PEM5H, PEM5F, L2EM3H	3.C(3). b. Fresh grass marsh	V.E. 16 Rooted fresh water communities & higher altitude forb forms
II.	a. Wet Sedge Tundra (non-complex)	84 Wet Tundra	V.A) Wet Sedge meadows includes smooth wet sedge meadows, low-centered polygon wet sedge meadows, and string bogs.	I. Flooded Tundra	PEM5E	3.C(1). a. Wet sedge meadow tundra 3.C(1). b. Wet sedge grass meadow tundra	V.C.8b. Graminoid sod-form tundra
	b. Wet Sedge Tundra (very wet complexes)	84 Wet Tundra	VI.B) Flooded Sedge Meadows	Complex of II. or IIb and Uplands	PSS1H / EM5 PEM5H / OW	Complexes dominated by 3.C.(1)a.	V.C.8b. Graminoid sod-form tundra; IV.E2b String bog
	c. Wet Sedge Tundra	84 Wet Tundra	V.A) Wet Sedge Meadows	Mostly Uplands	PSS1C / EM5 PSS1F / EM5	Complexex dominated by 3.C.(1)a.	V.C.8b. Graminoid sod-form tundra
	d. Wet Sedge Tundra (moist complexes)	84 Wet Tundra	V.B) Salt Grass Meadows	VIII Coastal Wetlands	E2EM5P	3.C.(4)e. Halophytic sedge wet meadows	V.C.8b. Graminoid sod-form tundra
IV.	a. Moist/Wet Sedge Tundra Complex	85 Mixed Tundra	VII. Intermediate Wet Moist Tundra	Complex of I. and Uplands	PSS1C / EM5 B, C or E	Complexes dominated by 3.C.(1)g. Sedge-willow tundra, or 3.C.(1)i. Sedge-dryas tundra	V.C.8b. Gramioid sod-form tundra

Table B-7.--Appropriate equivalent units in several systems of landcover, wetland, and vegetation classifications used in norther Alaska--Continued

	1981 ANWR Landsat classification	Other Remote Sensor Land Cover Classifications		Wetland Classifications		Vegetation Classifications	
		National USGS classification system Anderson and others (1976) Level II	ANWR Landsat classification Nodler and LaPerriere (1977)	Pt. Storkerson wetlands Bergman and others (1977)	National Wetland Inventory Cowardin and others (1979)	Alaska Viereck and others (Unpub. Manu. 1981) Level IV where possible	International UNESCO (1973)
VII.	c. Moist Tussock Sedge, Dwarf Shrub/Wet Dwarf Shrub Tundra Complex (water track complex)	82 Mixed Tundra	IV.B) Tussock Meadow	None	Complex of Upland and PSS1B / EM5	Complex of 3.C.(2)d. Sedge tussock-mixed shrub and 2.B.(3)n. Willow-sedge fen or 2.B.(2)a. Low willow	V.C.8a. Graminoid bunch-form tundra
VIII.	Shrub Tundra	82 Shrub Tundra	None	None	Upland	2.B.(2) Closed low shrub	III.B.3b subalpine or subpolar deciduous thicket
IX.	Partially vegetated area:						
	a. River Bars	77 Mixed Barren Land	IV. Partially vegetated ground	None	R4SB, R2FL, R3FL, R2BB, R3BB	Several types including: 3.D.(1)a. Serial herbs 2.C.(1)h. Prostrate shrubs and herbs on floodplains 2.B.(3)b. Low willow	V.D.2b(3) episodical forb communities III.B.3b subalpine or subpolar deciduous thicket
	b. Alpine Tundra	77 Mixed Barren Land	IV. Partially vegetated ground	None	Upland	Several types including: 3.D.(1)c. Alpine herbs 3.D.(1)b. Alpine herb-sedge (snowbed) 2.C.(1)i. Mat and cushion-sedge tundra 2.C.(1)k. Dryas tundra 3.E.(2)a. Crustose lichens	V.C.7b. Alpine and subalpine meadows of higher latitudes
	c. Sorted Stone Nets	77 Mixed Barren Land	IV. Partially vegetated ground	None	Upland	3.E.(2)a. Crustose lichens 2.C.(1)g. Open lichens	None
	d. Beaches	72 Beaches	IV. Partially vegetated ground	None	M2BBP, M2FLN, E2FLN	3.D.(3)d. Halophytic wet meadow	None

APPENDIX C

LETTERS

STATE OF ALASKA

DEPARTMENT OF NATURAL RESOURCES

DIVISION OF PARKS

JAY S. HAMMOND, GOVERNOR

619 WAREHOUSE DR., SUITE 210
ANCHORAGE, ALASKA 99501

PHONE: 274-4676

June 30, 1982

File No: 3130-1 (Fish & Wildlife Service)

Keith Schreiner
U.S. Fish & Wildlife Service
1011 E. Tudor Road
Anchorage, AK 99503

Dear Mr. Schreiner:

We have reviewed your plans for the identification and protection of archaeological and historic resources in the Arctic National Wildlife Refuge during oil and gas exploration.

Given the time constraints, the large areas involved, and the undetermined locations of exploration activities, we feel the plan outlined in your June 8 letter will effectively mitigate possible damage to cultural resources.

Some of our staff members have been involved with the Bureau of Land Management's efforts in the National Petroleum Reserve and have seen how well a similar plan can work. Consultation with the BLM is encouraged.

Concerning your archaeological consultants, we would like to see their research design and have the opportunity to consult with them where possible.

We would also like to see a map of the area where oil and gas exploration will be taking place and what sorts of activities are planned when that information is available.

Sincerely,

Timothy A. Smith, DEPUTY SHPO

FOR! Ty L. Dilliplane
State Historic Preservation Officer

TAS/jdg

ADDRESS ONLY THE DIRECTOR,
FISH AND WILDLIFE SERVICE

United States Department of the Interior

FISH AND WILDLIFE SERVICE
WASHINGTON D.C. 20240

U.S. Fish and Wildlife Service
RECEIVED
AUG 03 1982
Assistant Area Director - Fisheries/
Federal Assistance
JUL 28 1982

In Reply Refer To:
FWS/OES 7-82-22

Memorandum

To: Regional Director, Region 7 (ARD/AFF)

From: Chief, Office of Endangered Species

Subject: Intra-Service Section 7 Consultation, Oil and Gas Exploration in the Coastal Plain of the Arctic National Wildlife Refuge (ANWR)

This acknowledges receipt of your biological assessment dated June 17, 1982, and responds to your request for formal consultation pursuant to Section 7 of the Endangered Species Act of 1973, as amended. At issue is the effect of the proposed alternatives identified in the Preliminary Draft Environmental Impact Statement for Oil and Gas Exploration within the Coastal Plain of the Arctic National Wildlife Refuge, Alaska (Preliminary DEIS), relative to the listed Arctic peregrine falcon (Falco peregrinus tundrius).

On July 27, 1982, we completed an examination of the above action and reviewed the biological information provided by you along with information available in our files. The aforementioned biological assessment provided by the Region 7 Office reflects a careful and thorough analysis of the impacts of oil and gas exploration activities in the ANWR on the Arctic peregrine falcon. Consequently, much of the information utilized in the development of this biological opinion was extracted from the excellent assessment which you provided. In addition, Dennis Money and Mike Amaral, Endangered Species staff, Region 7 Office, were contacted.

Background

Section 1002 of the Alaska National Interest Lands Conservation Act provides for a comprehensive and continuing inventory and assessment of the fish and wildlife of the coastal plain of the ANWR and an analysis of the impacts of oil and gas exploration, development, and production. The proposed action described in the Preliminary DEIS is to carry out surface geological exploration or seismic exploration or both, for oil and gas within the coastal plain of the ANWR. The various exploration methods are discussed in detail in the Preliminary DEIS and will not be repeated here.

Biological Description - Arctic Peregrine Falcon

In Alaska, most peregrine falcons nest on ledges of cliffs or bluffs overlooking bodies of water. Rarely ground nests are utilized, such as nesting on tundra

hummocks. In the ANWR north of the Brooks Range, cliff habitat is not particularly abundant. However, a limited number of peregrines have been reported nesting there in past years (Cade, 1960; Roseneau et al., 1976).

The most recent survey of raptor habitat in the ANWR was conducted in August of 1980 by Roseneau et al. No nesting peregrines were found, although a survey done this late in the breeding season could have missed pairs that attempted to nest but were unsuccessful. Historically, peregrines were known to occupy eyries on the North Slope along the Canning, Katakturuk, Sadlerochit, Hulahula, Jago, Aichilik, and Kongakut Rivers within the Refuge (U.S. Fish and Wildlife Service (FWS) 1982 Baseline Study). Among the eyries formerly or potentially occupied by peregrines within the ANWR, only two are within the Arctic coastal plain study area. These sites occur on bluffs or cliffs along the Sadlerochit and Jago Rivers.

Peregrine falcons are highly migratory and spend a relatively short period of time in Alaska. Arctic peregrines generally arrive at their North Slope eyries between April 21 and May 7, egg-laying and incubation occur between May 15 and July 21, and young fledge (leave the nest) during August (FWS 1982 Baseline Study). In general, the breeding season is defined as the period from April 15 to August 31.

There appears to be a significant movement of Arctic peregrine falcons through the Arctic coastal plain from late August to mid-September (Martin and Moiteret, 1981; FWS 1982 Baseline Study). The number and timing of these observations strongly suggest that at least some North Slope Arctic peregrines are following a coastal migration route along the Beaufort Sea. The lagoons, river mouths, and bays concentrate large numbers of shorebirds and waterfowl which are favored prey of the peregrine.

Although the last documented nesting of peregrines in the ANWR north of the Continental Divide was in 1972-73 when three sites near the confluence of the Marsh Fork and Canning River were occupied (Roseneau, 1974), several more recent sightings during June and July have been reported from the Arctic coastal plain (FWS 1982 Baseline Study). The significance of these observations is unclear as the birds did not appear to be associated with nest sites. Yet, the observations do indicate that in addition to those present during migration, a few scattered peregrines can be found in the coastal plain during the breeding season.

Analysis of Potential Effects

A. Winter Operation (October - March)

As previously stated, Arctic peregrine falcons are migratory and occur in Alaska only during the breeding season (approximately mid-April to mid-September).

Thus we concur with your determination that the majority of activities associated with a winter exploration program will have no effect on the Arctic peregrine falcon. These activities include human movement, surface vehicle use, ice-airstrip construction, aircraft use, waste disposal, energy wave generation, and drilling shot holes. Winter activities that could affect peregrine falcons are listed below with a brief description of potential impacts.

1. Site developments (base camps, pads, storage areas, etc.): The presence of structures and equipment in close proximity to nest sites may discourage peregrines from occupying the nesting territory. No real effect is anticipated from site developments provided that they are temporary in nature (removed after the winter period) or, if semi-permanent, are located 2 or more miles from areas of potential nesting habitat.

2. Water withdrawal: Water withdrawal (of unknown quantity) will be a necessary activity at all field camps. Peregrine falcons feed on a variety of bird life, most species of which are strongly associated with water or wetland habitats. An activity that reduces the availability of water or wetland habitat near an eyrie or along a migration route could indirectly impact the peregrine by displacing potential prey species. However, given the lack of recent records of peregrines nesting within the coastal plain of the ANWR, that wetland habitat is abundant, and that existing data indicates that primary movement of migrating peregrines occurs along the Beaufort Sea shoreline, little or no impact from water withdrawal is expected.

3. Chemical Contamination: Contamination of peregrines or their prey could result from the use of herbicides, insecticides, or spillage of petro-chemicals or toxic wastes. Even limited applications of herbicides or insecticides are absorbed into the ecosystem. Such contaminants tend to concentrate in predators like the peregrine which are at the top of their food chain. Petro-chemical or toxic waste spills could also be accumulated by peregrines through ingestion of contaminated prey. All chemicals and toxicants (fuels, solvents, and lubricants) must be carefully handled and contained according to the draft regulations included in the Preliminary DEIS. With this provision, no effect on the Arctic peregrine falcon is anticipated.

B. Summer Operation (April - September)

The following discussion examines the potential impacts to peregrines of activities associated with a summer exploration period:

1. Human Movement: Human presence near eyries whether deliberate or inadvertent may disturb nesting peregrines. Frightened adults flushed

from an eyrie may cause injury or death to peregrine young or eggs. Peregrines sometimes temporarily desert an eyrie after a disturbance. This can result in overcooling, overheating, or excessive moisture loss from eggs; chilling, heat prostration, or malnutrition in young; or predation on eggs or young (Alaska Peregrine Falcon Recovery Team; Roseneau et al., 1980). Disturbance may also result in premature fledging causing injury or death to nestlings (Roseneau et al., 1980). Haugh and Halperin (1976) stated that the first sites to be deserted in an area are those eyries close to human activity.

2. Surface Vehicle Use: The preceding discussion would also be pertinent here. Surface vehicle use would also have a greater likelihood of disturbing waterfowl and other prey species utilized by the peregrine.

3. Aircraft Use: The use of either fixed or rotary wing aircraft near peregrine eyries may be taken as a threat and cause the falcon to flee the nesting area or attack the aircraft (Roseneau et al., 1980). However, Ellis (1981), in a recent study of peregrine and prairie falcon response to repeated military aircraft flights found that the birds quickly became habituated and suffered no loss of eggs, young, or reduction in reproductive success. Generally, the FWS recommends that aircraft maintain a minimum altitude of 1,500 feet within a 1-mile horizontal distance of peregrine nest sites.

4. Nautical Vessel Use: No effect on the Arctic peregrine falcon.

5. Site Developments: The construction of base camps, pads, and other facilities will likely have the same impacts on the Arctic peregrine falcon as those discussed in sections B1. and 2. above. Habitat loss associated with site developments would probably be of minor significance as long as the facility was not located within 2 miles of an eyrie or potential nesting habitat.

6. Water Withdrawal: See discussion under Winter Operation.

7. Waste Water Disposal: No effect on the Arctic peregrine falcon.

8. Chemical Handling and Storage: See discussion under Winter Operation.

9. Energy Wave Generation and Drilling Shot Holes: Loud noises in close proximity to eyries (or foraging areas) are apt to have a disturbing effect on peregrines. The nature of the disturbance, distance from the nest site, frequency, and intensity would all affect how a falcon would react to the disturbance. Reactions would be similar to those described in section B.1.

As previously mentioned, existing data indicate that peregrines are present in the study area during migration and during the breeding season, although current nesting within the coastal plain has not been confirmed. Inasmuch as Falco peregrinus populations are increasing elsewhere in Alaska, including those along the Colville, Yukon, Porcupine, and Tanana Rivers, suitable nesting habitat occurring within the Arctic coastal plain should be considered of unique importance. These areas include the foothills of the Sadlerochit Mountains where rivers have cut cliffs or bluffs in the coastal plain enroute to the sea. Sadlerochit Springs and the hillside at the Bitty benchmark on the Jago River should be considered of particular importance for their suspected past use by peregrines. The following restrictions should, at minimum, apply to these two locations.

Protective Restrictions

The biological assessment prepared by the Region 7 Office lists the following restrictions currently recommended by the FWS for the protection of peregrine falcon nest sites in Alaska:

1. Aircraft shall maintain 1,500 feet altitude (above nest level) within 1 mile horizontal distance of nest sites (eyries) from April 15 through August 31.

2. The use of explosives and other activities or facilities having noise levels which may result in disturbance to nesting efforts is prohibited within 2 miles of nest sites from April 15 through August 31, unless specifically authorized by the FWS through informal/formal consultation.

3. All ground level activity is prohibited within 1 mile of nest sites from April 15 through August 31, unless specifically authorized by the FWS through informal/formal consultation.

4. Additional permanent facilities and long-term habitat alterations (such as material sites, roads, and airstrips) are prohibited within 1 mile of nest sites, unless specifically authorized by the FWS through informal/formal consultation.

5. A survey of suitable nesting habitat in the Arctic coastal plain should be conducted each year to determine the presence of nesting peregrines.

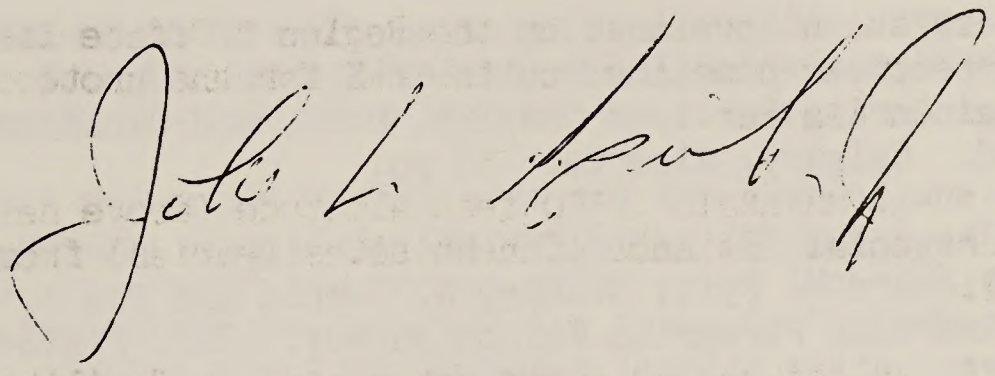
Biological Opinion

Both the winter and summer oil and gas exploration programs in the ANWR may affect the Arctic peregrine falcon. The Arctic peregrine is highly migratory and, although there is a significant movement of peregrines through the Arctic coastal plain from late August to mid-September, peregrines are absent from the

project area in the winter. While field observations indicate the presence of a few scattered peregrines in the ANWR coastal plain during the breeding season, no known nesting of peregrines has occurred in this area since 1972-73. With the application of the aforementioned protective restrictions to the Sadlerochit Springs and Bitty benchmark on the Jago River, and to any occupied eyries located through annual surveys, there should be no negative impacts to the peregrine falcon.

Therefore, it is my biological opinion that your action, as proposed, is not likely to jeopardize the continued existence of the Arctic peregrine falcon.

Should this action, as now planned, be modified or altered (including variances to the protective restrictions), or should new species be listed that may be affected, you must reinitiate consultation.



References Cited

Alaska Peregrine Falcon Recovery Team. 1982. Recovery Plan for the Peregrine Falcon - Alaska population (Falco peregrinus tundrius, Falco peregrinus anatum). U.S. Dept. of Int., FWS, Anch., AK. 84 pp.

Cade, T. J. 1960. Ecology of the peregrine and gyrfalcon populations in Alaska. Univ. of CA Pub. Zoology. 63(3):151-290.

Ellis, D. H. 1981. Responses of raptorial birds to low level military jets and sonic booms. Inst. for Raptor Stud. Rept. submitted to USFWS and U.S. Air Force. 59 pp.

Haugh, J. R. 1976. Recent history of peregrine falcons in the Tanana Valley, Alaska. State Univ. New York and AK Dept. Fish and Game Pub. 15 pp.

Martin, P. D. and C. S. Moitoret. 1981. Bird populations and habitat use, Canning River Delta, Alaska. USFWS unpubl. rept. Fairbanks, AK

Roseneau, D. G. 1974. A continuation of studies of raptorial bird nesting sites along proposed pipeline routes in Alaska. Unpubl. Rept. submitted to Northern Engineering Services Company, Ltd., and Canadian Arctic Gas Study Company, Ltd. Calgary, Alberta. 68 pp.

Roseneau, D. G., Reynolds, H. and C. M. White. 1976. Northeastern Alaska, p. 243-245 In Richard W. Fyfe, Stanley A. Temple and Tom J. Cade, editors, The 1975 North American Peregrine Falcon survey. Can. Field-Nat. 90(3):228-273.

Roseneau, D. G., P. J. Bente, and A. M. Springer. 1980. Numbers and status of Peregrine Falcons (Falco peregrinus) on the middle Yukon River, lower Yukon River, and in selected areas of the Arctic National Wildlife Refuge, Alaska, 1980. Unpubl. rept. submitted to USFWS, Anch., AK. 54 pp.

U.S. Department of the Interior. 1982. Arctic National Wildlife Refuge Coast Plain Resource Assessment; Baseline study; Fish, and Wildlife and their Habitats, Initial Report. FWS, Fairbanks, AK. 543 pp.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
P.O. Box 1668
Juneau, Alaska 99802

April 6, 1982

Mr. Keith Shreiner
Regional Director
U.S. Fish and Wildlife Service
1011 East Tudor Road
Anchorage, Alaska 99503

Dear Keith:

In reply to your letter of January 20 requesting information on endangered species present in or near the Arctic National Wildlife Refuge (ANWR), we are pleased to provide the following information.

Endangered species that may occur in this area are the bowhead whale (Balaena mysticetus) and the gray whale (Eschrichtius robustus). The bowhead whale is known to inhabit the waters offshore of the ANWR during its fall migration along the Beaufort Sea coast in September and October. It is often sighted along the 20-meter isobath which can be within 2 to 10 miles offshore in this area. The area off Demarcation Bay to the east of your study area has been found to be a feeding area for these whales during these months and portions of the coastal waters off the study area may also be used for this activity.

The gray whale is not a regular visitor to these waters, and would be unlikely to be encountered off the ANWR.

Onshore activites are unlikely to affect bowhead whales. The primary activities that we can foresee having any potential impacts are vessel and aircraft traffic in coastal waters, and possibly onshore blasting near the coast. Should such activities be proposed, we would wish to further discuss these matters with you.

Sincerely,

Bob

Robert W. McVey
Director, Alaska Region

APPENDIX D

ARCTIC NATIONAL WILDLIFE REFUGE
COASTAL PLAIN RESOURCE ASSESSMENT

Section 1002 of the Alaska National Interest Lands Conservation Act
(16 U.S.C. 3142)

ARCTIC NATIONAL WILDLIFE REFUGE
COASTAL PLAIN RESOURCE ASSESSMENT

Section 1002 of the Alaska National Interest Lands Conservation Act
(16 U.S.C. 3142)

Sec. 1002.(a) Purpose.--The purpose of this section is to provide for a comprehensive and continuing inventory and assessment of the fish and wildlife resources of the coastal plain of the Arctic National Wildlife Refuge; an analysis of the impacts of oil and gas exploration, development, and production, and to authorize exploratory activity within the coastal plain in a manner that avoids significant adverse effects on the fish and wildlife and other resources.

(b) Definitions.--As used in this section--

(1) The term "coastal plain" means that area identified as such in the map entitled "Arctic National Wildlife Refuge," dated August 1980.

(2) The term "exploratory activity" means surface geological exploration or seismic exploration, or both, for oil and gas within the coastal plain.

(c) Baseline Study.--The Secretary, in consultation with the Governor of the State, Native Village and Regional Corporations, and the North Slope Borough within the study area and interested persons, shall conduct a continuing study of the fish and wildlife (with special emphasis on caribou, wolves, wolverines, grizzly bears, migratory waterfowl, muskoxen, and polar bears) of the coastal plain and their habitat. In conducting the study, the Secretary shall--

(A) assess the size, range, and distribution of the populations of the fish and wildlife;

(B) determine the extent, location, and carrying capacity of the habitats of the fish and wildlife;

(C) assess the impacts of human activities and natural processes on the fish and wildlife and their habitats;

(D) analyze the potential impacts of oil and gas exploration, development, and production on such wildlife and habitats; and

(E) analyze the potential effects of such activities on the culture and lifestyle (including subsistence) of affected Native and other people.

Within eighteen months after the enactment date of this act, the Secretary shall publish the results of the study as of that date and shall thereafter publish such revisions thereto as are appropriate as new information is obtained.

(d) Guidelines.--(1) Within two years after the enactment date of this act, the Secretary shall by regulation establish initial guidelines governing the carrying out of exploratory activities. The guidelines shall be based upon the results of the study required under subsection (c) and such other information as may be available to the Secretary. The guidelines shall include such prohibitions, restrictions, and conditions on the carrying out of exploratory activities as the Secretary deems

necessary or appropriate to ensure that exploratory activities do not significantly adversely affect the fish and wildlife, their habitats, or the environment, including, but not limited to--

(A) a prohibition on the carrying out of exploratory activity during caribou calving and immediate post-calving seasons or during any other period in which human activity may have adverse effects;

(B) temporary or permanent closing of appropriate areas to such activity;

(C) specification of the support facilities, equipment and related manpower that is appropriate in connection with exploratory activity; and

(D) requirements that exploratory activities be coordinated in such a manner as to avoid unnecessary duplication.

(2) The initial guidelines prescribed by the Secretary to implement this subsection shall be accompanied by an environmental impact statement on exploratory activities. The initial guidelines shall thereafter be revised to reflect changes made in the baseline study and other appropriate information made available to the Secretary.

(e) Exploration Plans.--(1) After the initial guidelines are prescribed under subsection (d), any person including the United States Geological Survey may submit one or more plans for exploratory activity (hereinafter in this section referred to as "exploration plans") to the Secretary for approval. An exploration plan must set forth such information as the Secretary may require in order to determine whether the plan is consistent with the guidelines, including, but not limited to--

(A) a description and schedule of the exploratory activity proposed to be undertaken;

(B) a description of the equipment, facilities, and related manpower that would be used in carrying out the activity;

(C) the area in which the activity would be undertaken; and

(D) a statement of the anticipated effects that the activity may have on fish and wildlife, their habitats and the environment.

(2) Upon receiving any exploration plan for approval, the Secretary shall promptly publish notice of the application and the text of the plan in the Federal Register and newspapers of general circulation in the State. The Secretary shall determine, within one hundred and twenty days after any plan is submitted for approval, if the plan is consistent with the guidelines established under subsection (d). If the Secretary determines that the plan is so consistent, he shall approve the plan: except that no plan shall be approved during the two-year period following the date of enactment of this act. Before making the determination, the Secretary shall hold at least one public hearing in the State for purposes of receiving the comments and views of the public on the plan. The Secretary shall not approve of any plan submitted by the United States Geological Survey unless he determines that (1) no other person has submitted a plan for the area involved which meets

established guidelines and (2) the information which would be obtained is needed to make an adequate report under subsection (h). The Secretary, as a condition of approval of any plan under this section--

(A) may require that such modifications be made to the plan as he considers necessary and appropriate to make it consistent with the guidelines;

(B) shall require that all data and information (including processed, analyzed and interpreted information) obtained as a result of carrying out the plan shall be submitted to the Secretary; and

(C) shall make such data and information available to the public except that any processed, analyzed and interpreted data or information shall be held confidential by the Secretary for a period of not less than two years following any lease sale including the area from which the information was obtained.

(f) Modification To Exploration Plans.--If at any time while exploratory activity is being carried out under an exploration plan approved under subsection (e), the Secretary, on the basis of information available to him, determines that continuation of further activities under the plan or permit will significantly adversely affect fish or wildlife, their habitat, or the environment, the Secretary may suspend the carrying out of activities under the plan or permit for such time, make such modifications to the plan or to the terms and conditions of the permit (or both suspend and so modify) as he determines necessary and appropriate.

(g) Civil Penalties.--(1) Any person who is found by the Secretary, after notice and an opportunity for a hearing in accordance with section 554 of title 5, United States Code, to have violated any provision of a plan approved under subsection (e) or any term or condition of a permit issued under subsection (f), or to have committed any act prohibited under subsection (d) shall be liable to the United States for a civil penalty. The amount of the civil penalty shall not exceed $10,000 for each violation. Each day of a continuing violation shall constitute a separate offense. The amount of such civil penalty shall be assessed by the Secretary by written notice. In determining the amount of such penalty, the Secretary shall take into account the nature, circumstances, extent, and gravity of the prohibited act committed, and, with respect to the violator, the history of any prior offenses, his demonstrated good faith in attempting to achieve timely compliance after being cited for the violation, and such other matters as justice may require.

(2) Any person against whom a civil penalty is assessed under paragraph (1) may obtain review thereof in the appropriate district court of the United States by filing a notice of appeal in such court within thirty days from the date of such order and by simultaneously sending a copy of such notice by certified mail to the Secretary. The Secretary shall promptly file in such court a certified copy of the record upon which such violation was found or such penalty imposed, as provided in section 2112 of title 28, United States Code. The findings and order of the Secretary shall be set aside by such court if they are not found to be supported by substantial evidence, as provided in section 706(2)(E) of title 5, United States Code.

(3) If any person fails to pay an assessment of a civil penalty against him under paragraph (1) after it has become final, or after the appropriate court has

entered final judgment in favor of the Secretary, the Secretary shall refer the matter to the Attorney General of the United States, who shall recover the amount assessed in any appropriate district court of the United States. In such action, the validity and appropriateness of the final order imposing the civil penalty shall not be subject to review.

(4) The Secretary may compromise, modify, or remit, with or without conditions, any civil penalty which is subject to imposition or which has been imposed under this subsection unless the matter is pending in court for judicial review or recovery of assessment.

(h) Report to Congress.--Not earlier than five years after the enactment date of this act and not later than five years and nine months after such date, the Secretary shall prepare and submit to Congress a report containing--

(1) the identification by means other than drilling of exploratory wells of those areas within the coastal plain that have oil and gas production potential and estimate of the volume of the oil and gas concerned;

(2) the description of the fish and wildlife, their habitats, and other resources that are within the areas identified under paragraph (1);

(3) an evaluation of the adverse effects that the carrying out of further exploration for, and the development and production of, oil and gas within such areas will have on the resources referred to in paragraph (2);

(4) a description of how such oil and gas, if produced within such area, may be transported to processing facilities;

(5) an evaluation of how such oil and gas relates to the national need for additional domestic sources of oil and gas; and

(6) the recommendations of the Secretary with respect to whether further exploration for, and the development and production of, oil and gas within the coastal plain should be permitted and, if so, what additional legal authority is necessary to ensure that the adverse effects of such activities on fish and wildlife, their habitats, and other resources are avoided or minimized.

(i) Effect of Other Laws.--Until otherwise provided for in law enacted after the enactment date of this act, all public lands within the coastal plain are withdrawn from all forms of entry or appropriation under the mining laws, and from operation of the mineral leasing laws, of the United States.

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VEGETATION AND LAND COVER
ARCTIC NATIONAL WILDLIFE REFUGE
COASTAL PLAIN, ALASKA

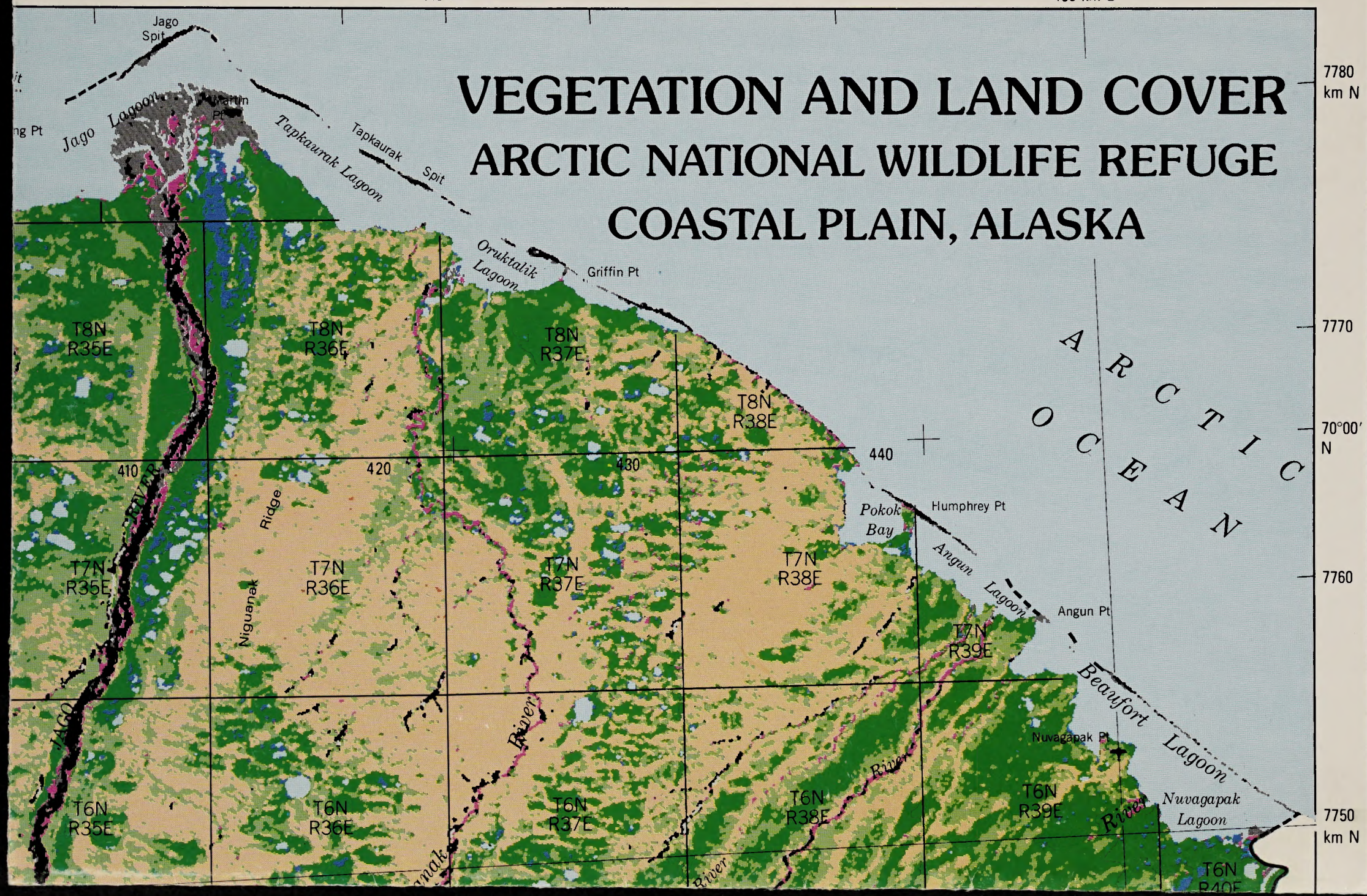

PLATE 1

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
UNITED STATES FISH AND WILDLIFE SERVICE AND
THE UNITED STATES ARMY COLD REGIONS RESEARCH AND ENGINEERING LABORATORY

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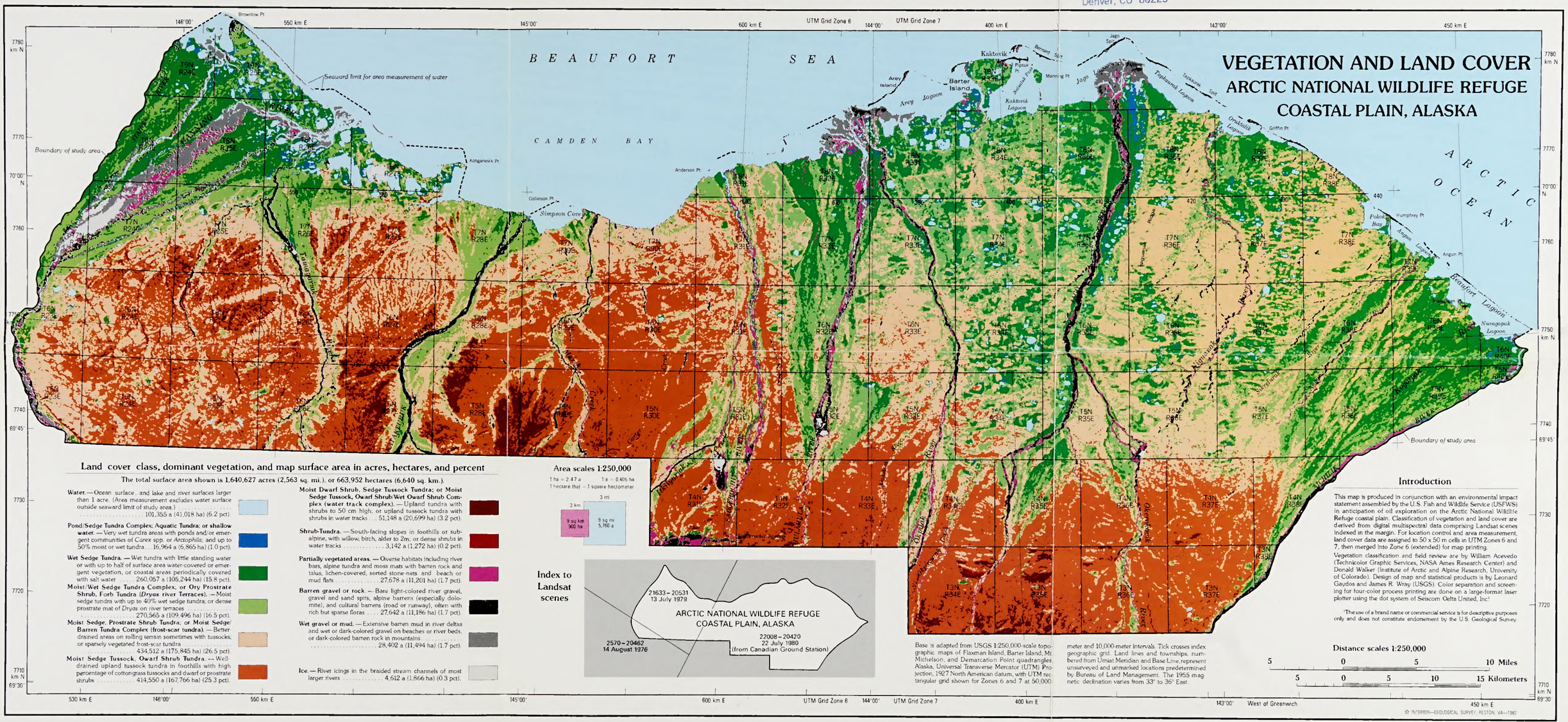
VEGETATION AND LAND COVER, ARCTIC NWR, ALASKA
MAP I–1443

VEGETATION AND LAND COVER
ARCTIC NATIONAL WILDLIFE REFUGE
COASTAL PLAIN, ALASKA



Land cover class, dominant vegetation, and map surface area in acres, hectares, and percent

The total surface area shown is 1,640,627 acres (2,563 sq. mi.), or 663,952 hectares (6,640 sq. km.).

Water. — Ocean surface, and lake and river surfaces larger than 1 acre. (Area measurement excludes water surface outside seaward limit of study area.) . . . . . 101,355 a (41,018 ha) (6.2 pct).

Pond/Sedge Tundra Complex; Aquatic Tundra; or shallow water. — Very wet tundra areas with ponds and/or emergent communities of *Carex* spp. or *Arctophila*; and up to 50% moist or wet tundra . . . 16,964 a (6,865 ha) (1.0 pct).

Wet Sedge Tundra. — Wet tundra with little standing water or with up to half of surface area water-covered or emergent vegetation, or coastal areas periodically covered with salt water . . . . . 260,057 a (105,244 ha) (15.8 pct).

Moist/Wet Sedge Tundra Complex; or Dry Prostrate Shrub, Forb Tundra (*Dryas* river Terraces). — Moist sedge tundra with up to 40% wet sedge tundra; or dense prostrate mat of *Dryas* on river terraces . . . . . 270,565 a (109,496 ha) (16.5 pct).

Moist Sedge, Prostrate Shrub Tundra; or Moist Sedge/Barren Tundra Complex (frost-scar tundra). — Better-drained areas on rolling terrain sometimes with tussocks; or sparsely vegetated frost-scar tundra . . . . . 434,512 a (175,845 ha) (26.5 pct).

Moist Sedge Tussock, Dwarf Shrub Tundra. — Well-drained upland tussock tundra in foothills with high percentage of cottongrass tussocks and dwarf or prostrate shrubs . . . . . 414,550 a (167,766 ha) (25.3 pct).

Moist Dwarf Shrub, Sedge Tussock Tundra; or Moist Sedge Tussock, Dwarf Shrub/Wet Dwarf Shrub Complex (water track complex). — Upland tundra with shrubs to 50 cm high, or upland tussock tundra with shrubs in water tracks . . . 51,148 a (20,699 ha) (3.2 pct).

Shrub-Tundra. — South-facing slopes in foothills or subalpine, with willow, birch, alder to 2m, or dense shrubs in water tracks . . . . . 3,142 a (1,272 ha) (0.2 pct).

Partially vegetated areas. — Diverse habitats including river bars, alpine tundra and moss mats with barren rock and talus, lichen-covered, sorted stone-nets and beach or mud flats . . . . . 27,678 a (11,201 ha) (1.7 pct).

Barren gravel or rock. — Bare light-colored river gravel, gravel and sand spits, alpine barrens (especially dolomite), and cultural barrens (road or runway), often with rich but sparse floras . . . . 27,642 a (11,186 ha) (1.7 pct).

Wet gravel or mud. — Extensive barren mud in river deltas and wet or dark-colored gravel on beaches or river beds, or dark-colored barren rock in mountains . . . . . 28,402 a (11,494 ha) (1.7 pct).

Ice. — River icings in the braided stream channels of most larger rivers . . . . . 4,612 a (1,866 ha) (0.3 pct).

Area scales 1:250,000

1 ha = 2.47 a 1 a = 0.405 ha
1 hectare (ha) = 1 square hectometer

Index to Landsat scenes

Introduction

This map is produced in conjunction with an environmental impact statement assembled by the U.S. Fish and Wildlife Service (USFWS) in anticipation of oil exploration on the Arctic National Wildlife Refuge coastal plain. Classification of vegetation and land cover are derived from digital multispectral data comprising Landsat scenes indexed in the margin. For location control and area measurement, land cover data are assigned to 50 x 50 m cells in UTM Zones 6 and 7, then merged into Zone 6 (extended) for map printing.

Vegetation classification and field review are by William Acevedo (Technicolor Graphic Services, NASA Ames Research Center) and Donald Walker (Institute of Arctic and Alpine Research, University of Colorado). Design of map and statistical products is by Leonard Gaydos and James R. Wray (USGS). Color separation and screening for four-color process printing are done on a large-format laser plotter using the dot system of Seiscom Delta United, Inc[1].

[1]The use of a brand name or commercial service is for descriptive purposes only and does not constitute endorsement by the U.S. Geological Survey.

Base is adapted from USGS 1:250,000-scale topographic maps of Flaxman Island, Barter Island, Mt Michelson, and Demarcation Point quadrangles, Alaska, Universal Transverse Mercator (UTM) Projection, 1927 North American datum, with UTM rectangular grid shown for Zones 6 and 7 at 50,000-meter and 10,000-meter intervals. Tick crosses index geographic grid. Land lines and townships, numbered from Umiat Meridian and Base Line, represent unsurveyed and unmarked locations predetermined by Bureau of Land Management. The 1955 magnetic declination varies from 33° to 36° East.

Distance scales 1:250,000

5 0 5 10 Miles
5 0 5 10 15 Kilometers

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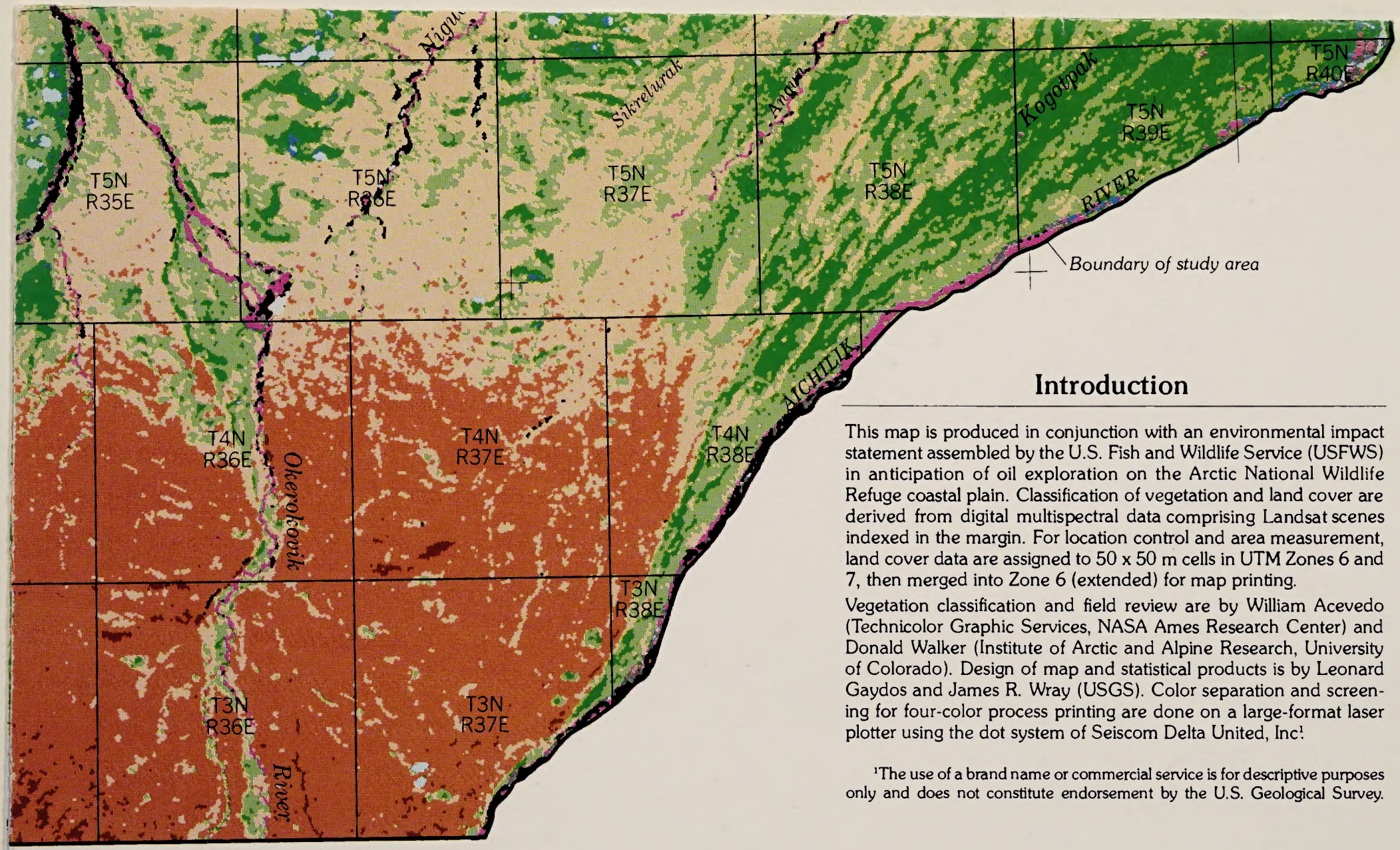
PLATE 1



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Distance scales 1:250,000

5 0 5 10 Miles

5 0 5 10 15 Kilometers

7740
69°45′
7730
7720
7710 km N
69°30′

143°00′ West of Greenwich 450 km E

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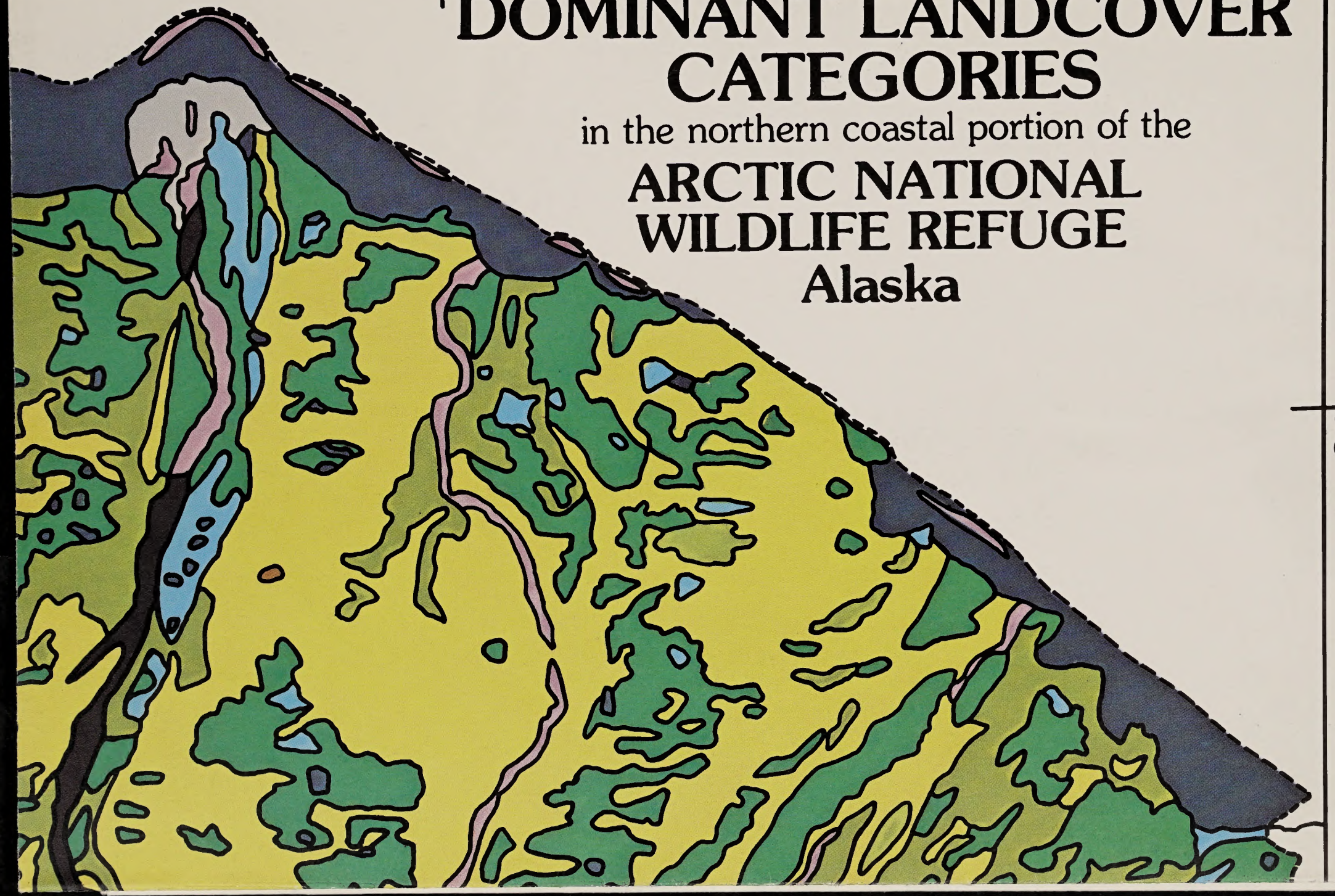
143° West of Greenwich

DOMINANT LANDCOVER CATEGORIES

in the northern coastal portion of the

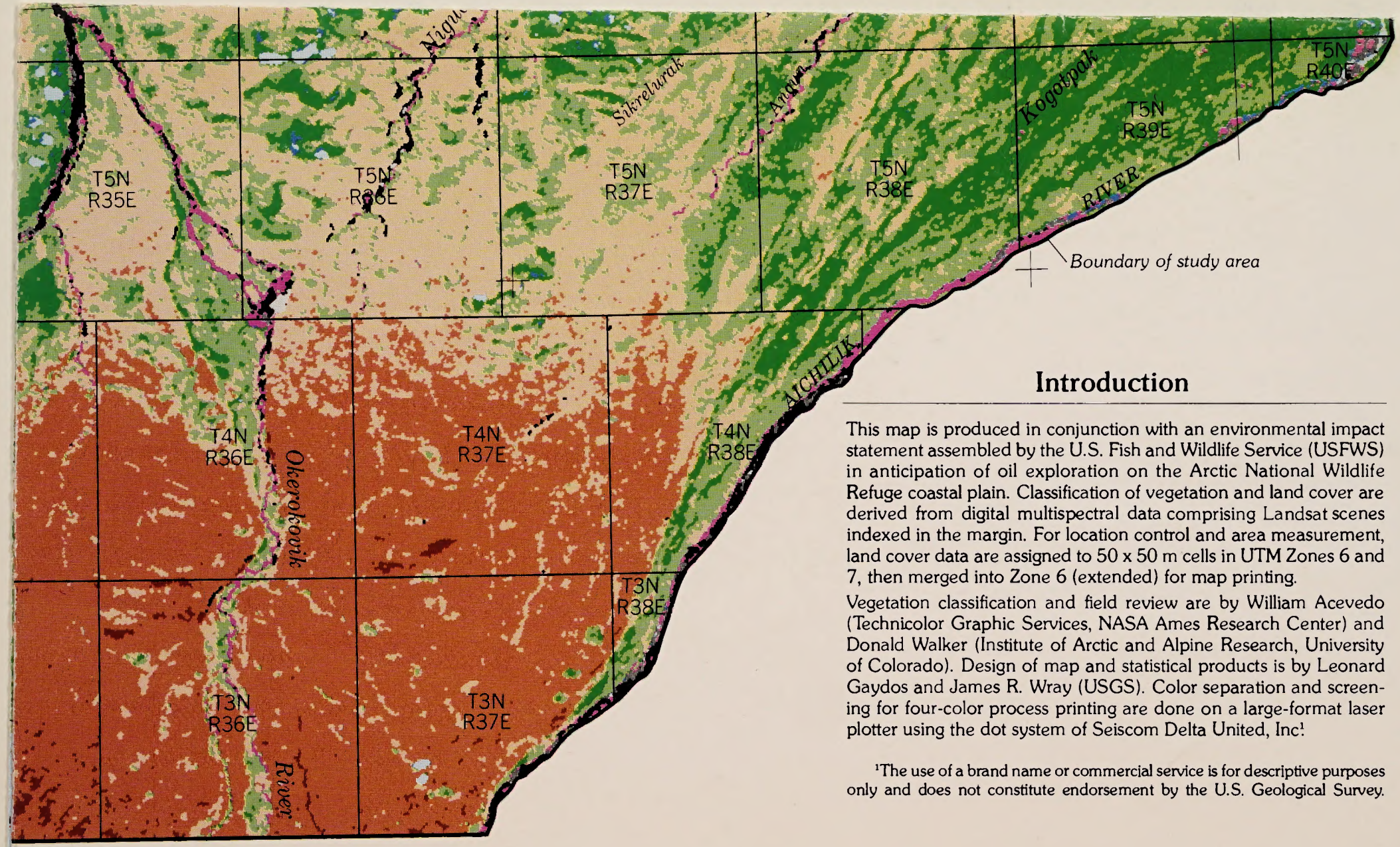
ARCTIC NATIONAL WILDLIFE REFUGE

Alaska



70° 00′

PLATE 2



Introduction

This map is produced in conjunction with an environmental impact statement assembled by the U.S. Fish and Wildlife Service (USFWS) in anticipation of oil exploration on the Arctic National Wildlife Refuge coastal plain. Classification of vegetation and land cover are derived from digital multispectral data comprising Landsat scenes indexed in the margin. For location control and area measurement, land cover data are assigned to 50 x 50 m cells in UTM Zones 6 and 7, then merged into Zone 6 (extended) for map printing.

Vegetation classification and field review are by William Acevedo (Technicolor Graphic Services, NASA Ames Research Center) and Donald Walker (Institute of Arctic and Alpine Research, University of Colorado). Design of map and statistical products is by Leonard Gaydos and James R. Wray (USGS). Color separation and screening for four-color process printing are done on a large-format laser plotter using the dot system of Seiscom Delta United, Inc[1].

[1]The use of a brand name or commercial service is for descriptive purposes only and does not constitute endorsement by the U.S. Geological Survey.

meter and 10,000-meter intervals. Tick crosses index geographic grid. Land lines and townships, numbered from Umiat Meridian and Base Line, represent unsurveyed and unmarked locations predetermined by Bureau of Land Management. The 1955 magnetic declination varies from 33° to 36° East.

Distance scales 1:250,000

5 0 5 10 Miles

5 0 5 10 15 Kilometers

7740
69°45′
7730
7720
7710
km N
69°30′

143°00′ West of Greenwich 450 km E

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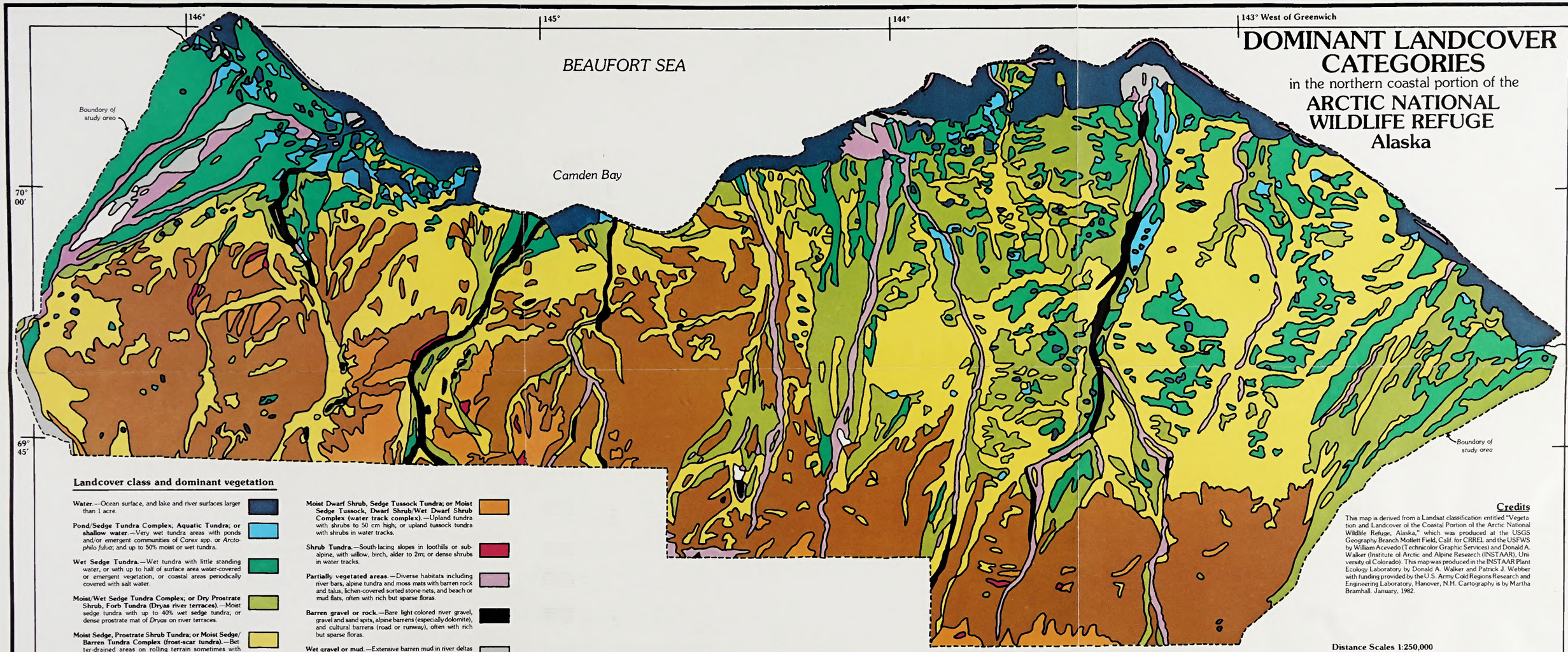
Denver, CO 80225

DOMINANT LANDCOVER CATEGORIES

in the northern coastal portion of the

ARCTIC NATIONAL WILDLIFE REFUGE

Alaska



Landcover class and dominant vegetation

Water.—Ocean surface, and lake and river surfaces larger than 1 acre.

Pond/Sedge Tundra Complex; Aquatic Tundra; or shallow water.—Very wet tundra areas with ponds and/or emergent communities of *Carex* spp. or *Arctophila fulva*; and up to 50% moist or wet tundra.

Wet Sedge Tundra.—Wet tundra with little standing water, or with up to half of surface area water-covered or emergent vegetation, or coastal areas periodically covered with salt water.

Moist/Wet Sedge Tundra Complex; or Dry Prostrate Shrub, Forb Tundra (Dryas river terraces).—Moist sedge tundra with up to 40% wet sedge tundra; or dense prostrate mat of *Dryas* on river terraces.

Moist Sedge, Prostrate Shrub Tundra; or Moist Sedge/Barren Tundra Complex (frost-scar tundra).—Better-drained areas on rolling terrain sometimes with cottongrass tussocks; or sparsely vegetated frost-scar tundra.

Moist Sedge Tussock, Dwarf Shrub Tundra.—Well-drained upland tussock tundra in foothills with high percentage of cottongrass tussocks and dwarf or prostrate shrubs.

Moist Dwarf Shrub, Sedge Tussock Tundra; or Moist Sedge Tussock, Dwarf Shrub/Wet Dwarf Shrub Complex (water track complex).—Upland tundra with shrubs to 50 cm high; or upland tussock tundra with shrubs in water tracks.

Shrub Tundra.—South-facing slopes in foothills or subalpine, with willow, birch, alder to 2m; or dense shrubs in water tracks.

Partially vegetated areas.—Diverse habitats including river bars, alpine tundra and moss mats with barren rock and talus, lichen-covered sorted stone nets, and beach or mud flats, often with rich but sparse floras.

Barren gravel or rock.—Bare light-colored river gravel, gravel and sand spits, alpine barrens (especially dolomite), and cultural barrens (road or runway), often with rich but sparse floras.

Wet gravel or mud.—Extensive barren mud in river deltas and wet or dark-colored gravel on beaches or river beds, or dark-colored barren rock in mountains.

Ice.—River icings in the braided stream channels of most of the larger rivers.

Credits

This map is derived from a Landsat classification entitled "Vegetation and Landcover of the Coastal Portion of the Arctic National Wildlife Refuge, Alaska," which was produced at the USGS Geography Branch Moffett Field, Calif. for CRREL and the USFWS by William Acevedo (Technicolor Graphic Services) and Donald A. Walker (Institute of Arctic and Alpine Research (INSTAAR), University of Colorado). This map was produced in the INSTAAR Plant Ecology Laboratory by Donald A. Walker and Patrick J. Webber with funding provided by the U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, N.H. Cartography is by Martha Bramhall. January, 1982.

Base is adapted from USGS 1:250,000-scale topographic maps of Barter Island, Flaxman Island, Demarcation Point, and Mt. Michelson quadrangles, Alaska.

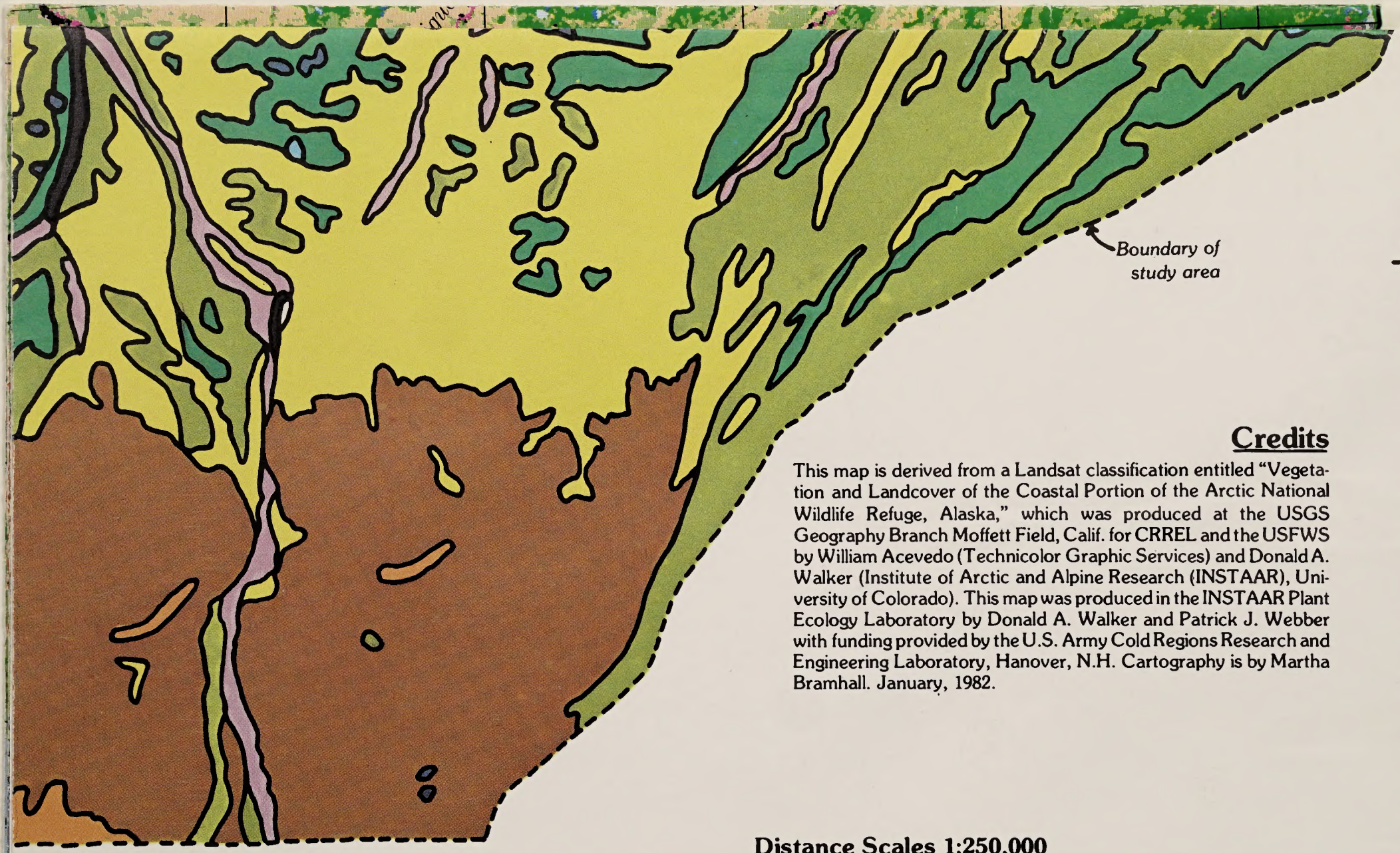
Distance Scales 1:250,000

5 0 5 10 Miles

5 0 5 10 15 Kilometers

PLATE 2

* U.S. Government Printing Office:1982--578-253



Boundary of study area

69° 45′

Credits

This map is derived from a Landsat classification entitled "Vegetation and Landcover of the Coastal Portion of the Arctic National Wildlife Refuge, Alaska," which was produced at the USGS Geography Branch Moffett Field, Calif. for CRREL and the USFWS by William Acevedo (Technicolor Graphic Services) and Donald A. Walker (Institute of Arctic and Alpine Research (INSTAAR), University of Colorado). This map was produced in the INSTAAR Plant Ecology Laboratory by Donald A. Walker and Patrick J. Webber with funding provided by the U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, N.H. Cartography is by Martha Bramhall. January, 1982.

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Distance Scales 1:250,000

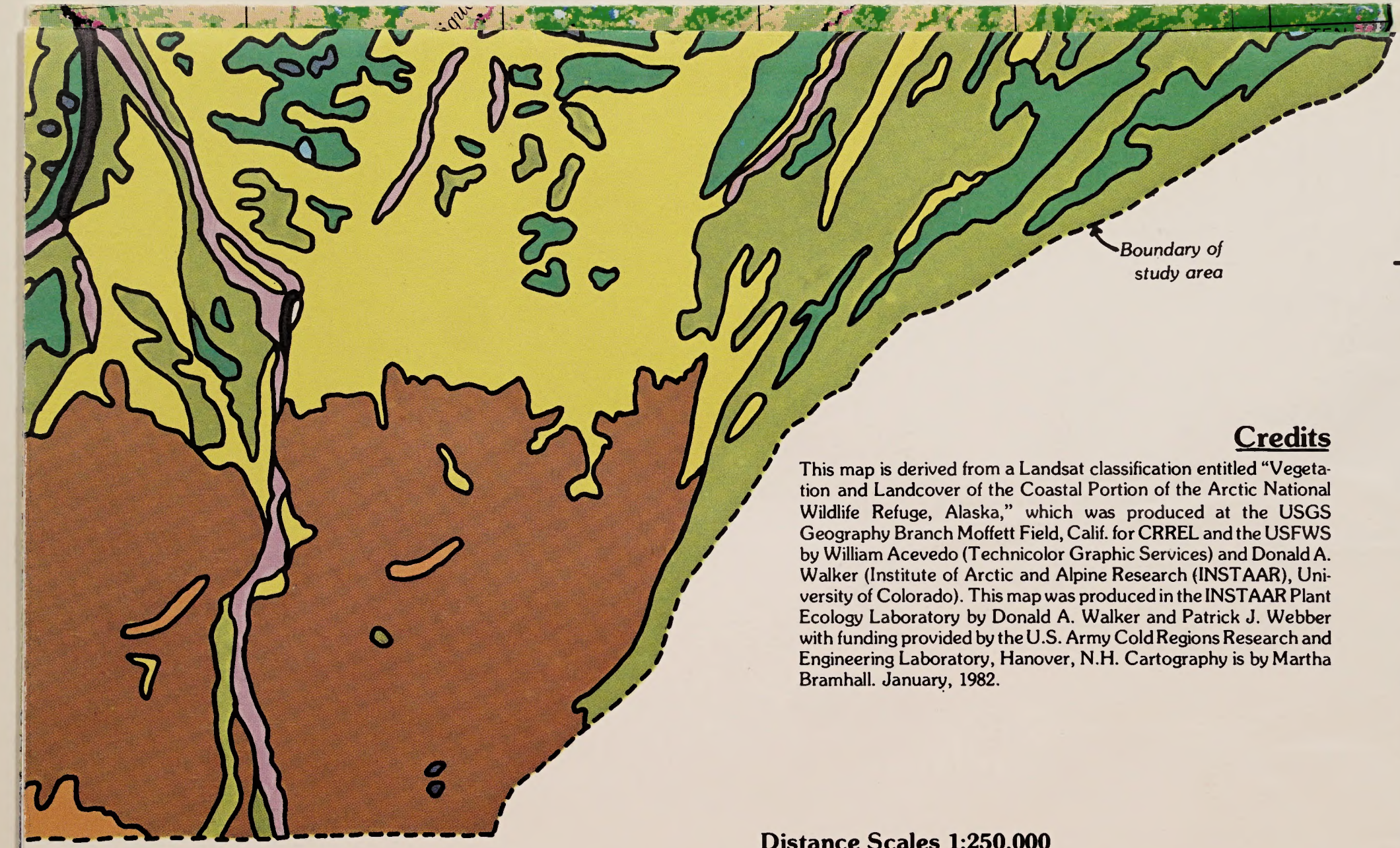
5 0 5 10 **Miles**

5 0 5 10 15 **Kilometers**

143° West of Greenwich

69° 30′ N

* U.S. Government Printing Office:1982--578-253



69°
45′

Credits

This map is derived from a Landsat classification entitled "Vegetation and Landcover of the Coastal Portion of the Arctic National Wildlife Refuge, Alaska," which was produced at the USGS Geography Branch Moffett Field, Calif. for CRREL and the USFWS by William Acevedo (Technicolor Graphic Services) and Donald A. Walker (Institute of Arctic and Alpine Research (INSTAAR), University of Colorado). This map was produced in the INSTAAR Plant Ecology Laboratory by Donald A. Walker and Patrick J. Webber with funding provided by the U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, N.H. Cartography is by Martha Bramhall. January, 1982.

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Distance Scales 1:250,000

5 0 5 10 **Miles**

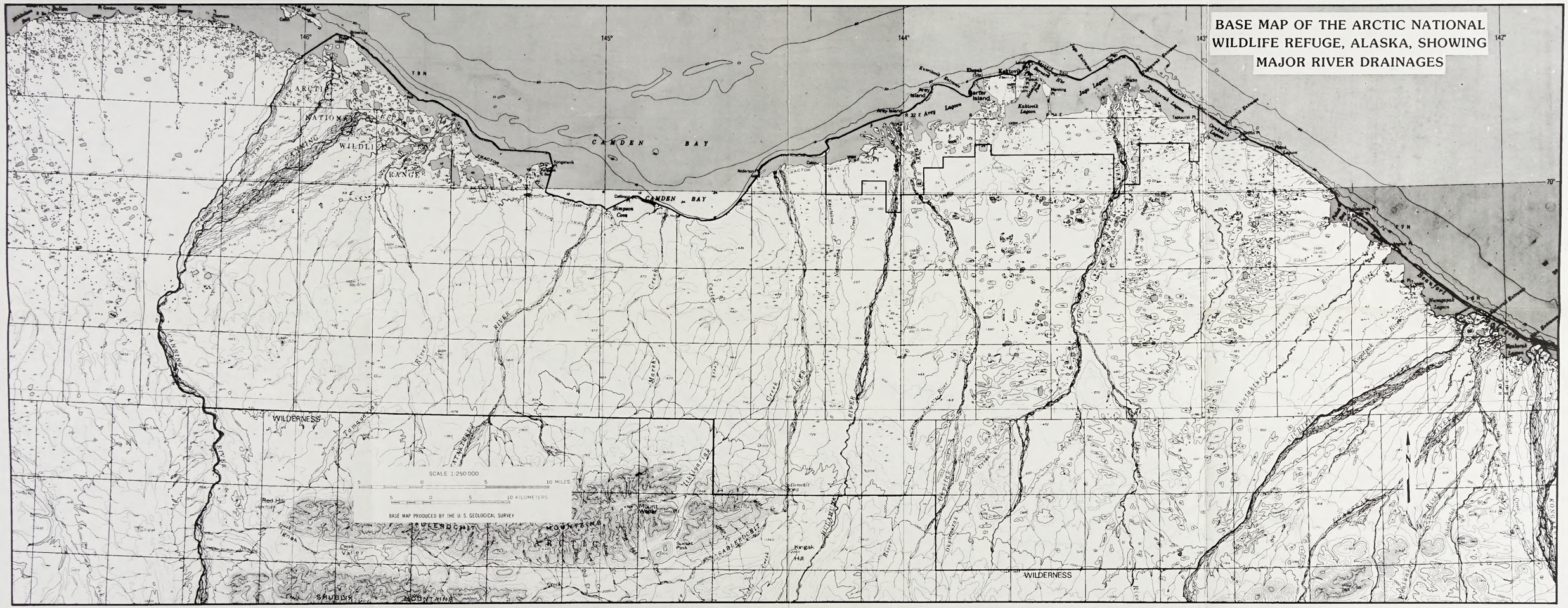
5 0 5 10 15 **Kilometers**

143° West of Greenwich

69° 30′ N

* U.S. Government Printing Office:1982--578-253

BASE MAP OF THE ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, SHOWING MAJOR RIVER DRAINAGES



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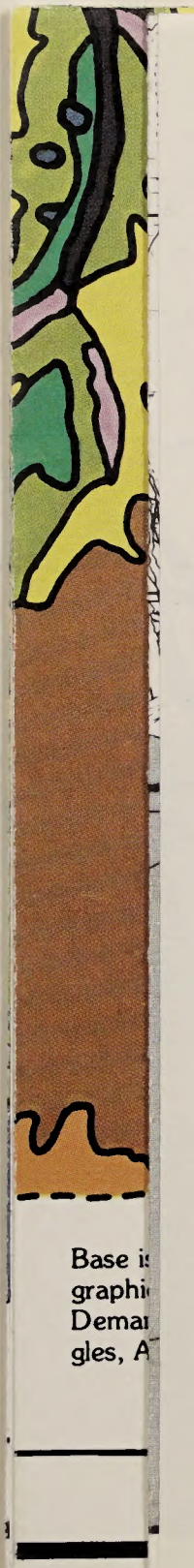

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